BUILDER 3 & 2

PREPARED BY

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

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PREFACE

This book is written for men of the Navy and of the Naval Reserve who are studying for advancement to the rates of Builder 3 and 2. Combined with the necessary practical experience and a thorough study of the Basic Navy Training Courses, the information in this Training Course will help prepare the reader for advancement in rating examinations.

The first chapter of this book contains general information concerning the work and responsibilities of the Builder, a brief discussion of his place in the Construction Battalion and naval organization, and reference to a valuable supply of source material. Chapters 3, 4, and 5 are especially concerned with the duties of the Builder Light. Chapter 16 is concerned with the basic duties of the Builder Heavy . Safety precautions and first aid are stressed in all chapters.

As one of the NAVY TRAINING COURSES, this book was prepared by the U. S. Navy Training Publications Center for the Bureau of Naval Personnel, with technical assistance from the Bureau of Yards and Docks.

STUDY GUIDE

The table below indicates which chapters of this book apply to your rating. To use the table, follow these rules:

1. Select the column which applies to your rating. If you are in the Regular Navy you will use the column headed "BU" which is the general service rating. If you are a member of the Naval Reserve you will use the column headed by your particular emergency service rating — BUL or BUH.
2. Observe which chapters have been marked in your *rating* column with the number of the *rate* to which you are seeking advancement.
3. Study those particular chapters. They include information which will assist you in meeting the qualifications for your rating. (See Appendix II of this book for a complete list of qualifications for advancement in rating.) In order to gain a well-rounded view of the duties of the general service rating, it is recommended that you read the other chapters of this book even though they do not pertain directly to your rating.
4. Here is an example: If you are a member of the Naval Reserve studying for advancement in rating to Builder H (Heavy Construction) third you will select the column headed BUH. Following this column down **you will observe that you must study chapters 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17.**

CHAPTER	BU	BUL	BUH
1	3, 2	3, 2	3, 2
2	3, 2	3, 2	3, 2
3	3, 2	3, 2	3, 2
4	2	2	2
5	2	2	2
6	3, 2	3, 2	3, 2
7	3, 2	3, 2	3, 2
8	3, 2	3, 2	3, 2
9	3, 2	3, 2	3, 2
10	3, 2	3, 2	3, 2
11	3, 2	3, 2	3, 2
12	3, 2	3, 2	3, 2
13	3, 2	3, 2	3, 2
14	3, 2	3, 2	------
15	3, 2	3, 2	3, 2
16	3, 2	------	3, 2
17	3, 2	3, 2	3, 2

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READING LIST

NAVY TRAINING COURSES

Blueprint Reading, NavPers 10077
Basic Hand Tool Skills, NavPers 10085
Steelworker 3 & 2 (Chapters 7, 8), NavPers 10653–A

OTHER PUBLICATIONS

Pontoon Gear Handbook, NavDocks TP–PL–7

USAFI TEXTS

United States Armed Forces Institute (USAFI) courses for additional reading and study are available through your Information and Education Officer.* A partial list of those courses applicable to the Builder rating follows:

CORRESPONDENCE COURSES

Number	Title
CC 756	*Carpentry I*
CA 758	*Masonry I*
CA 764	*Basic Construction Work*

SELF-TEACHING

MC 756	*Carpentry I*
MA 758	*Masonry I*

*"Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services, and materials if the orders calling them to active duty specify a period of 120 days or more, or if they have been on active duty for a period of 120 days or more, regardless of the time specified in the active duty orders."

CHAPTER I

THE BUILDER IN THE NAVY

YOUR JOB

The construction battalions of World War II achieved a remarkable record in fulfilling their mission. Naval bases, similar to large cities, were built in a very short time. Their performances, both in combat and in construction, will long be remembered by the American people.

From bases built by the Seabees, on ice fields and on tropical jungle islands, our forces attacked and defeated the enemy. You can be proud that you are a Seabee. The construction battalion was of great value to your Nation in war. In times of peace, the mission of the battalion is equally important, for it must train its members to meet any emergency.

The Navy depends on you to carry on this splendid tradition. This book has been written to assist you in

your mission. You can learn how to do your job well by:

1. Observing building operations.
2. Asking questions.
3. Actual experience and practice.
4. Becoming "building-minded."
5. Studying this book.

This book will help you qualify for advancement to Builder 3 or 2 and get the increase in pay that goes with the rate.

THE BUILDER RATINGS

Builders in the construction battalions are classified under three ratings—one general service rating, and two emergency service ratings. The GENERAL SERVICE RATING combines the skills, duties, and knowledges necessary to work on both light and heavy construction, while the EMERGENCY SERVICE RATINGS are divided into the Builder Light (BUL) and Builder Heavy (BUH). Builders L will be trained to work on light construction, such as buildings, warehouses, and hospitals. Builders H will acquire the skills necessary to work on heavy construction, such as wharves, docks, cofferdams, and trestles.

Builder 3

As a competent Builder, you are a worker skilled in carpentry. You take pride in knowing the various kinds of structural timber. You are familiar with all the tools—both hand and machine—which may be found in a carpenter shop. You are well acquainted with the tools found in the dock builder's kit and can read simple blueprints and drawings of construction work. In addition to this, you are familiar with rigging and the use of simple tackle. All these increase your ability to help in the construction and erection of simple framing and heavy timbers.

A Builder Third is also a concrete worker. You must know how to operate, clean, and maintain concrete mixers

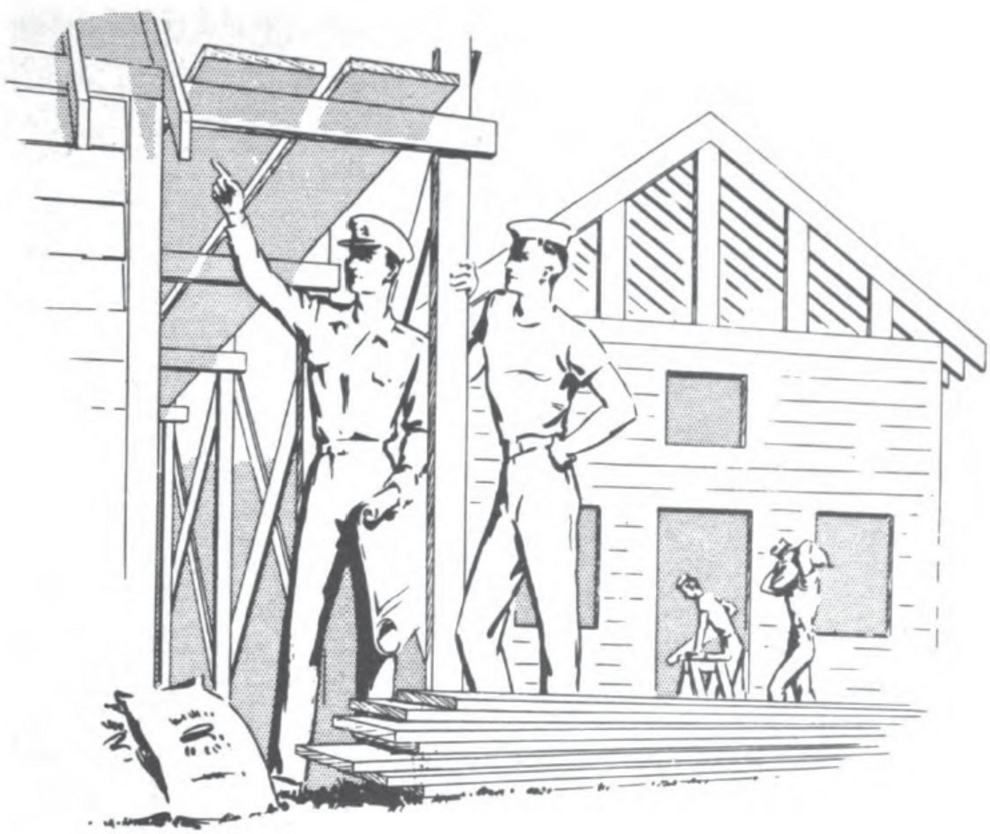


Figure 1–1.—Observation—study.

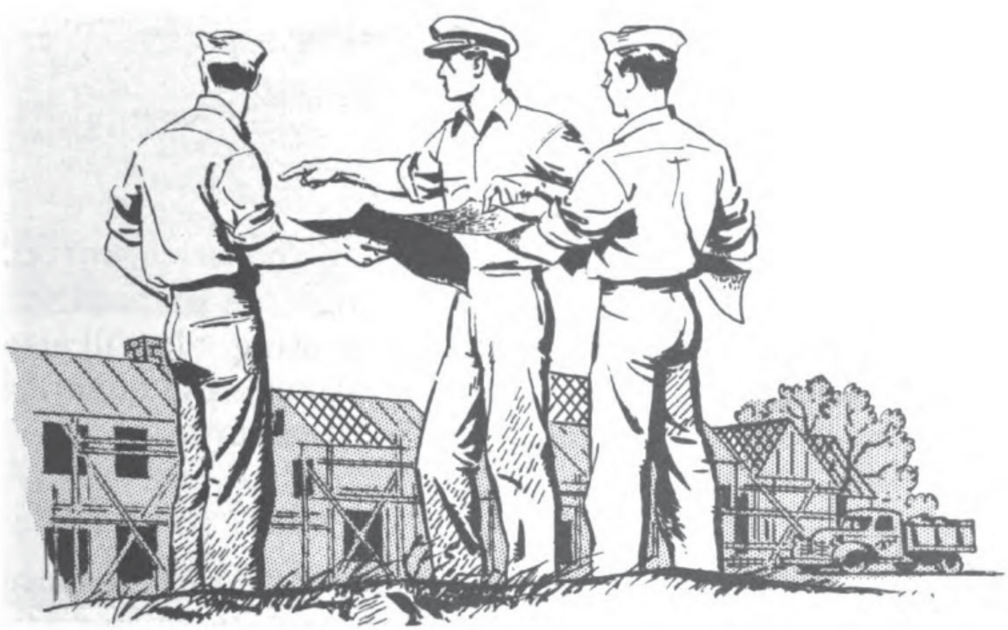


Figure 1–2.—Asking questions

and vibrators. Performing and interpreting slump tests on concrete are essential parts of your work. You should be able to direct the charging of a concrete mixer according to instructions and mix specifications.

And last, but not least, you should understand the basic principles of exterior and interior painting. This involves

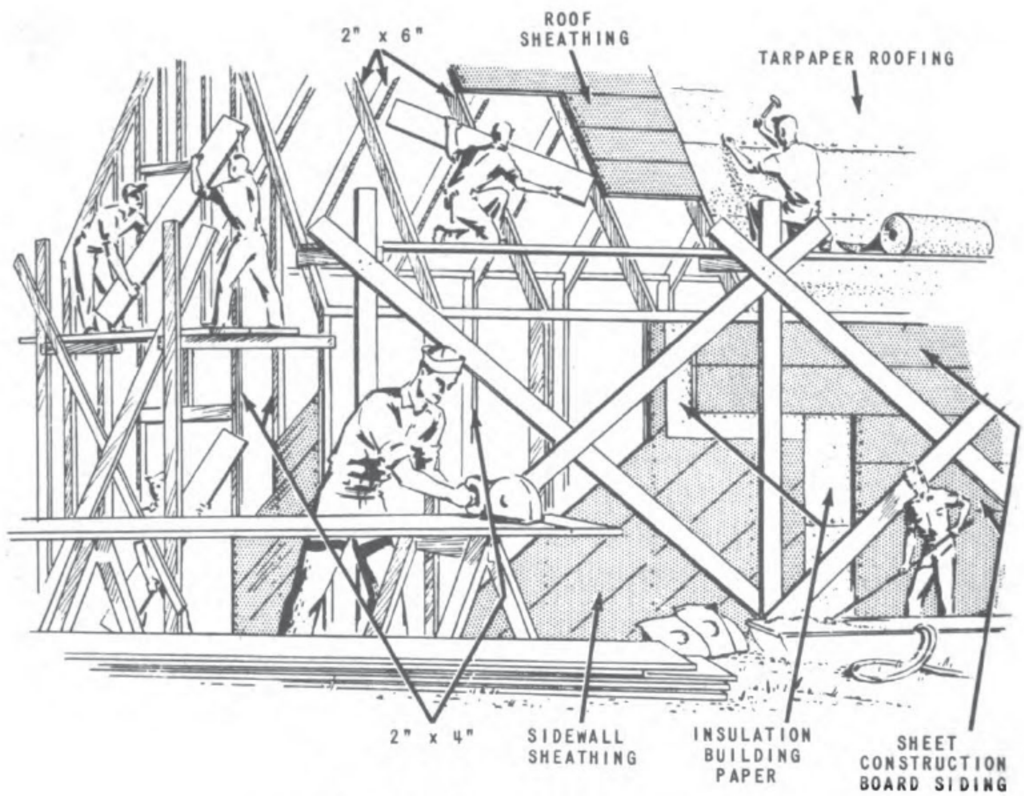


Figure 1-3.—Experience and practice.

the care of brushes; mixing formulae for brick, metal, and wooden surfaces; color mixing; and the preparation of plaster ceilings and sidewalls for painting. It will also include the know-how necessary to estimate the quantity of paint needed for the painting of a structure.

Builder 2

To qualify for Builder 2, you not only must become more skilled in all of the duties of the third-class rate, but you also must learn some new skills and be able to assume

more responsibility. You must know more about your job than you did to get your third-class rate.

1. Do you know how to read and work from blueprints used in construction?

2. Are you sufficiently acquainted with the operation and care of planers, band saws, joiners, sanders, and other shop equipment?

3. How familiar are you with the construction and use of A-frames, or with the signals used in loading and unloading construction material by cranes?

4. Do you know how to construct building framing? Are you familiar with the installation of frames, partitions, braces, joists, and subfloors?

5. Are you familiar with the construction of water front structures? Have you acquired the skills necessary to build wharves, docks, fenders, trestles, and cofferdams?

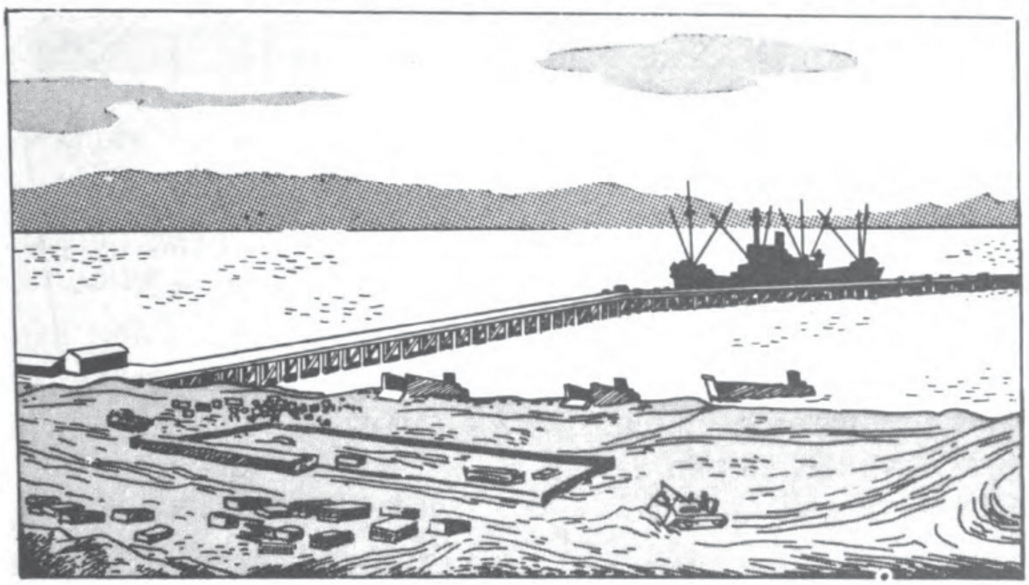


Figure 1-4.—Waterfront structure.

6. Do you know the terms and methods of pile driving? Would you be capable of acting as a groundman for a pile-driving crew?

7. Have you sufficient know-how to construct, maintain, and repair prefabricated structures? Are you familiar with the construction of field-type structures?

8. Are you acquainted with the methods of finishing concrete to required grade and type of surface, and with directing placing operations?

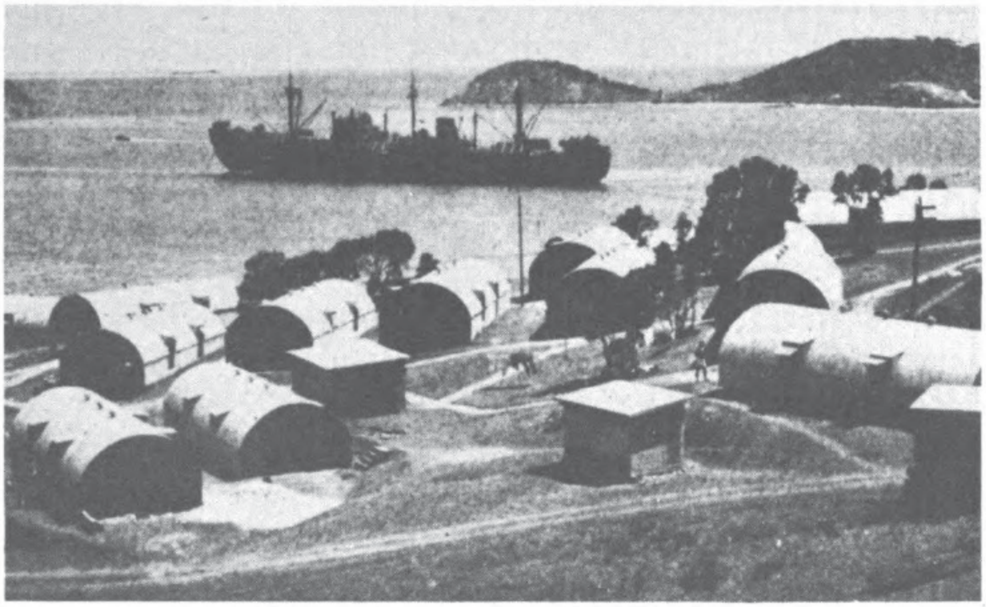


Figure 1–5.—Quonset huts.

9. Do you know how to prepare surfaces for painting and varnishing? What are the purposes served by linseed oil and turpentine in paint?

When you have acquired the necessary skills and can answer all the above questions, you will be ready to qualify in the practical factors and examination subjects for advancement in rating.

THE BUREAU OF YARDS AND DOCKS

Right now, your sights are set on the rating of Builder 3 or Builder 2. While climbing the ladder up to this point, you have become acquainted with the Navy and Seabees in general. Regular Navy, Naval Reserve, and active duty are familiar terms. But what about the part that your cognizant Bureau, the Bureau of Yards and Docks, plays in the Defense Organization as a whole?

As you know, the President of the United States is the Commander in Chief of the Armed Forces. One of the members of the cabinet is the Secretary of Defense, a civilian who heads the Department of Defense. This Department includes the following:

1. Department of the Air Force
2. Department of the Army
3. Department of the Navy

The Department of the Navy, frequently referred to as the Naval Establishment, includes the Navy Department (the Navy's administrative office in Washington, D. C.), the Shore Establishment (the naval districts and shore stations in the United States and some outlying areas), and the Operating Forces (the fleet). One of the bureaus of the Navy Department is the Bureau of Yards and Docks (BuDocks), which exercises technical control over the organization, equipment, and operational procedures of the naval construction forces. These forces are your Seabees.

BuDocks has the management control of the activities of the Shore Establishment which are concerned with organizing and equipping the Seabees, such as the construction battalion centers (CB centers) at Port Hueneme, California, and Davisville, Rhode Island.

The Chief of the Bureau of Yards and Docks is the Chief of Civil Engineers, and as such is the senior officer of the Civil Engineer Corps (the CEC). CEC officers are staff corps officers of the Navy. They are assigned to duty with the Bureau of Yards and Docks and are engaged in planning and research to determine the best methods of constructing and maintaining naval bases and activities. Since the CEC officer is the shore construction officer of the Navy, the Seabee battalion is staffed almost entirely with officers of this corps. Of course, each battalion also has other staff corps officers such as medical, dental, and supply officer. However, your commanding officer, execu-

tive officer, and company commanders will be CEC officers, trained especially to supervise the installation and maintenance work which you will perform.

NAVAL CONSTRUCTION FORCES

The naval construction forces (NCF) are fleet units of the Operating Forces and are assigned to fleet commands by the Chief of Naval Operations (CNO), who is the top ranking officer of the Navy. For example, an amphibious construction battalion is an element of a naval beach group under the Commander, Amphibious Force, who is responsible to the commander in chief of the fleet. A mobile construction battalion (MCB) in the Atlantic Fleet is under Commander, Construction Battalions, U. S. Atlantic Fleet (ComCBLant) who is under Commander, Service Force, U. S. Atlantic Fleet (ComServLant) who is in turn responsible to the Commander in Chief, U. S. Atlantic Fleet (CinCLant).

If an MCB in the Atlantic were to build an airstrip in North Africa, CNO would order the Atlantic Fleet to send a battalion to the area, but the Atlantic Division of the Bureau of Yards and Docks would provide the plans and materials for the job. From this example, you can readily see that the military command of the Seabees is exercised by the fleet. While on the other hand, the technical control is exercised by DuDocks.

Seabee Rating Assignments

The Navy rating structure is divided into occupational groups of ratings such as deck, administrative, aviation, etc. The group VIII (construction) ratings are those commonly called the Seabee ratings. Men with Seabee ratings may be assigned to shore stations in the United States, to overseas bases, or to fleet units other than the naval construction forces. But most men with Seabee ratings are assigned to Seabee-type activities. Seabee-

type activities include mobile construction battalions, amphibious construction battalions, CB maintenance units, and various kinds of CB detachments, some of which are created as the need arises and are then disestablished after accomplishing their purpose. When more than one battalion is needed for a big job, or when it is administratively desirable, regiment and brigade commands are established, consisting of a number of battalions or other Seabee-type units. The battalion is the basic Seabee organization and most Seabees are in the MCB's. The officers of other Seabee-type units usually follow a battalion-type organization; therefore, the discussion that follows will be concerned with an MCB which will serve as a typical example of Seabee units.

Battalion Organization

You have already discovered that a Seabee battalion is a highly organized unit. Every man's job, from that of the commanding officer to that of the newest recruit, has been studied and analyzed so that the whole organization will be as perfect as possible in every detail. In peacetime, a mobile construction battalion may consist of 368 to 768 men and 16 officers. In wartime, however, the MCB may be made up of as many as 1,082 men and 33 officers. The battalion is divided into companies and the companies are further divided into platoons. An MCB consists of a headquarters company and four lettered construction companies, A, B, C, and D.

The Navy has, for the most part, left the organization of the battalion up to the commanding officer. This flexibility permits the CO and his officers to gain the best use of men and materials for each operation. The Bureau of Yards and Docks, however, has published organizational guides to assist the commanding officer. These guides, plus the experience of individual officers and the Seabees as a whole, form the basis for battalion organization. The battalion is usually considered as having two organiza-

tions: the military organization for muster, military formations, and, in time of war, defensive combat; and the operational organization for construction jobs.

The Military Organization

The military organization is essentially an infantry battalion, and practically all battalions have the same basic military organization. This consists of five companies: Headquarters Company and four rifle companies designated A, B, C, and D.

The Operational Organization

For the construction or operational organization, two basic types of organization may be considered: the company system and the project system.

In the company system the officers and men of the military company work as a unit or group of work crews on various projects. The operations officer (usually the third ranking officer) manages the engineering office and advises the CO on the organization of jobs, priorities, etc. The CO assigns jobs to the company commanders who are in charge of the jobs and they assign men from their companies to the projects. Headquarters Company contains the service elements: engineering, special services, medical, dental, supply, and security sections. A Company usually has most of the Drivers and Mechanics and handles transportation, equipment operations, and equipment repair; the A Company commander has the title transportation officer, transportation and heavy equipment officer, or equipment operations officer. B Company has most of the Utilities Men and Construction Electrician's Mates and contains the electrical, plumbing, sheet metal, blacksmith, welding, carpenter and other shops; the B Company commander usually has the title of shops officer. C and D companies, called construction companies, have

most of the Builders and Steelworkers, and erect structures on the job site.

In the project system the operations officer is in overall charge of the jobs and assigns men from the battalion as a whole to various crews. A project officer is put in charge of a job without regard to company assignment. Headquarters Company is organized on the company system basis but the other military companies contain about an equal number of men without regard to rating. A Builder might be in A Company under one officer for mustering purposes but work in a crew that is headed by a project officer who happens to be the D Company commander. The shops personnel would be drawn from all the companies, but the shops officer would not necessarily be a B Company officer. The organization of most battalions falls somewhere between the basic systems described.

RECOMMENDED READING

A competent builder, when he has a problem to solve, knows where to find aids for the proper solution. He has a ready reference library at his home and on the job. The Navy has made the same library facilities available to you. You can obtain useful reference books from your Information and Education Officer. *Basic Hand Tool Skills,* NavPers 10085, contains advice on the handling of such general-purpose tools as hammers, screwdrivers, pliers, and others. This manual also includes a special chapter on hand tools used in woodworking, which describes the correct method of using hand saws, planes, wood chisels, and other work tools. *Blueprint Reading,* NavPers 10077, contains information on a working-drawing blueprint. *Mathematics, Vol. 1,* NavPers 10069–A, and *Mathematics, Vol. 2,* NavPers 10070–A, are valuable reference books since a knowledge of mathematics is fundamental to the Builder's rating. Blueprints used in erecting structures and the like are made as scale

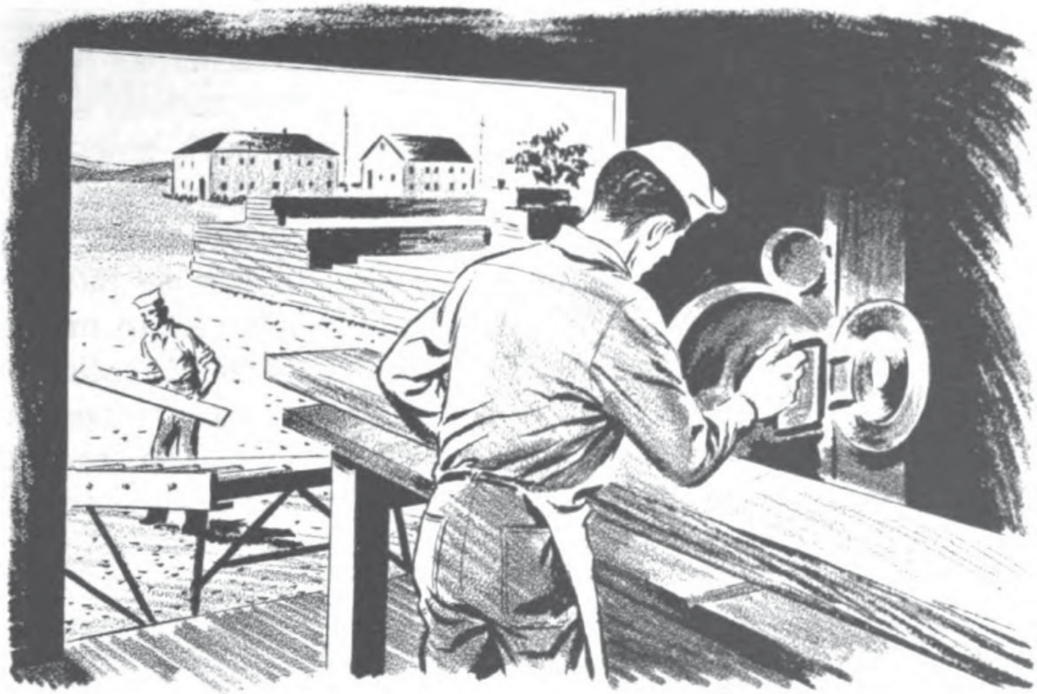
drawings. Be sure to study chapter 9 in *Mathematics, Vol. 1,* so you will know how to work with scale drawings.

LEADER OF MEN

And remember, there are some general things every petty officer is supposed to know and be able to do. These are not specific duties of your rating, but are requirements of all petty officers. A petty officer should be able to take charge of a group of men. He is expected to be able to show his men how the work must be done. He should know about first aid. He should know what is expected of him in helping to maintain order. Such information is given in the *General Training Course for Petty Officers,* NavPers 10055. It is a good idea, also, to be familiar with the *Bluejackets' Manual.* These references are mentioned to help you keep in mind some of the specific responsibilities which you have as a petty officer. Look at the petty officers around you. Learn to do what the best of them do.

QUIZ

1. How can you learn to do your job well?
2. What skills, duties, and knowledges does the general service rating combine?
3. How is the emergency service rating for Builder divided?
4. Who is the Commander in Chief of the Armed Forces?
5. What bureau exercises technical control over the Seabees?
6. What three departments comprise the Department of Defense?
7. What is the basic organization of the Seabees?
8. What two types of organization are used for the operational organization of the Seabees?
9. What will aid a Builder in solving his building problems?
10. What important information will you obtain from chapter 9, *Mathematics, Vol. 1?*



CHAPTER 2

LUMBER

ADVANTAGES OF WOOD

Paul Bunyan and his legendary lumberjacks have given way to the march of time, but the great lumber industry still carries on. Over a million builders both in the Navy and out, are making structures and housing from wooden materials.

Since ancient times, men have used wood for construction work. Wood was available, light, and strong. It was easily worked with hand tools to any desired shape or size. Today wood is still extensively used. It is comparatively inexpensive, and is obtainable in many shapes, sizes, and forms. In furniture, flooring, and paneling, a highly finished surface showing the wood grain adds up to beauty and attractiveness.

SOFTWOOD AND HARDWOOD

Wood used for building shelves, furniture, lockers,

staging, and shore construction jobs is classified as being either SOFTWOOD or HARDWOOD. These two terms, while used extensively by builders and woodworkers, are used more as a matter of convenience than as exact classification terms. As a matter of fact, this classification does not depend so much on how hard the wood is as it does on what kind of leaves the tree had. If the tree had broad leaves that were shed in the winter, the wood is called a hardwood. If it had needle leaves and cones or was an evergreen tree, the wood is called a softwood. The trouble with this system is that some of the so-called softwoods are just as hard as some of the hardwoods.

WOODS USED IN BUILDING FRAMING

YELLOW PINE (HARD PINE) is hard and strong. It is one of our most important building materials for heavy construction and exterior work. It is frequently used in railroad ties, wood trim, shipbuilding, docks, and bridges. Another major Navy use is for shores, wedges, plugs, strongbacks, and staging.

DOUGLAS FIR is an excellent structural lumber because it is strong, light, and easy to work. Its main use is in the construction of small buildings but it is sometimes used for deck planking on large ships. On small boats, filling pieces and bulkheads may be made of fir. Most of the plywood used for construction is also made of fir.

SPRUCE is divided into three varieties, red, white and black. All three kinds are easy to work, light in weight, and of medium strength. The colors of the three varieties run from light yellow to light brown. These woods are used chiefly for framing and mill work, and also for making boxes and crates.

SITKA SPRUCE, a light brown wood, has a coarse and straight grain. It is easy to work and also easy to handle being very light in weight. Because of its durability and medium strength, this wood is frequently used for wood trim, sash, doors, siding, and for exterior and interior

finish. You'll find it an excellent wood for making boxes and ladders.

HEMLOCK is reddish brown in color and light in weight. It is a difficult wood to work, splits easily, but holds nails well. This wood is generally used for framing, sheathing, roofing and subflooring.

WOODS USED IN BUILDING TRIM

WHITE PINE (SOFT PINE) is one of the patternmaker's favorites because it is easy to work, has a fine grain, is free of knots, and takes an excellent finish. It's an excellent lumber for almost any interior or exterior job that doesn't require maximum strength. White pine is easy to work. This wood is used in the making of doors, window sash, blinds and interior finish.

BASSWOOD—light brown—is easily worked and bends without splitting. This wood, with a grain that is straight and close, is light in weight and very tough. It is used in the making of picture frames, toys, fruit baskets and boxes. It is also used for making some types of inexpensive furniture and in some cabinet work.

CHESTNUT—reddish brown—is easy to work although it splits easily. Because of the chestnut's resistance to decay, it is used mainly for poles and fence posts.

The various species of OAK are divided into two groups, red oak and white oak. Red oak is reddish brown while white oak is light brown to whitish in color. White oak is difficult to work, therefore red oak is used more frequently for construction work. Red oak is used as a material for timbers, piling and heavy construction. Builders frequently use oak for interior wood trim and flooring.

MAPLE is fine-grained wood that makes excellent furniture, high-grade floors, bowling pins, and counter tops. Handles for tools may be made of maple, oak, birch, walnut and other woods, but the best handles are made of HICKORY. It hasn't been long since Navy carpenters made their own tool handles, but now they are bought

"ready made" and the most you will have to do is fit them.

BIRCH is a hard, durable wood with a fine, close grain. It takes a high polish and is used for cabinet work and to make imitation mahogany furniture. Wood dowels are often made of birch. Capping and other boat trim may be made of birch. BEECH is similar to birch but it is not so durable when exposed to the weather.

WHITEWOOD—yellow brown with a creamy white sapwood—is strong, soft and light in weight. This wood is easily worked, easy to glue, holds nails well and does not split readily. Whitewood is mainly used in interior wood trim, boats, cabinet work and cheaper furniture.

WOODS USED IN CABINETMAKING

BLACK WALNUT is a fine cabinet wood used for making expensive furniture, cabinets, interior woodwork, and gunstocks. It is somewhat coarse-grained but takes a beautiful finish when the pores are closed with woodfiller.

CHERRY is another fine cabinet wood. Its properties are similar to those of maple and birch. This wood is strong, medium in weight, and splits readily, but is easily worked.

RED CEDAR is fairly strong and hard, splits in nailing, is easy to work and has a straight grain. It is used for interior finish, chests, shingles, siding, poles and posts.

MISCELLANEOUS WOODS

CYPRESS has much the same characteristics as white cedar though it has greater utility due to its superior strength. Most Navy small boats are planked either with cypress or white cedar. Cypress offers great resistance to decay and is used for doors, porch materials, water tanks, shingles, posts, sash and siding.

WHITE CEDAR is a soft, light-weight, close-grained wood which is exceptionally durable when exposed to water. You'll find that many small boats are planked with this wood. It is not strong enough for building construction but it is used extensively for railroad ties, shingles,

and other items because of its good weather resistance.

LOCUST is heavy, strong, hard, and is from a yellow to a brown in color. The wood splits in nailing and is hard to work. Locust is used in shipbuilding, heavy construction, fence posts and poles.

HICKORY—a dark brown—is hard to work and almost impossible to nail. This wood, heavy, strong and hard, is mainly used to make handles for axes, picks, sledges and hatchets. Our best wooden golf club shafts are made from hickory. Rungs of most of the ladders used in construction work are made from this wood.

ASH, the white variety, is used to make oars, boat thwarts, side benches, gratings, and other interior boat fittings. Incidentally, it makes good ball bats, too. It is a heavy, strong, hard, tough, and elastic wood. It takes an excellent finish, either natural or painted, and lasts well even when it is not finished.

MAHOGANY, one of the best hardwoods obtainable for making furniture and boats, is imported from Honduras, Mexico, Central America, Central Africa, and other tropical sections. It has a brown to red color, is hard and durable, does not split badly, and takes a beautiful finish when the grain is filled. Any time you see an unusually beautiful boat, with natural-finish planking and decking, you can be pretty sure it is made of mahogany. The wood commonly called PHILIPPINE MAHOGANY is not a true mahogany and lacks many of the valuable properties of the real thing. The so-called Philippine mahogany has a greater tendency to shrink, expand, and warp. However, because it grows abundantly and is available in long, wide, clear boards, it is used extensively for making small pleasure boats and medium-grade furniture.

POPLAR is classed as a hardwood but it is comparatively soft. It has a tendency to warp, shrink and rot easily. Since, however, it is cheap and obtainable in wide, long boards, it is used in low-grade furniture and cheaply-constructed buildings.

TEAK comes from such places as India, Burma, Thailand, and Java. It is excellent for deck planking of ships and for shaft logs of small boats. It is a light brown color and is strong, easily worked, and unusually durable. It is highly resistant to damage caused by moisture. The flight deck of the Saratoga is planked with teak.

LIGNUM-VITAE is a dark-brown wood that is unusually hard, close-grained, and heavy. It weighs almost twice as much as oak. It is used for block sheaves and for the water-exposed shaft bearings of small boats.

REDWOOD is used for the same purposes as yellow pine and fir. But it is considered inferior to both because of its tendency to split and shrink and because it is extremely soft. It is, however, used extensively on the West coast where it is produced.

HOW A TREE GROWS

Any piece of wood is made up of a number of small cells. The size and arrangement of the cells determine the GRAIN of the wood and many of its properties. Examine a freshly cut tree stump—you'll see that the millions of small cells are arranged in circular rings around the pith or center of the tree. These rings are caused by a difference in the rate of growth of the tree during the various seasons of the year. In spring a tree grows rapidly and builds up a thick layer of comparatively soft, large cells. They appear in the cross section of the trunk as the LIGHT-COLORED annual rings.

As the weather gets hotter through the early summer, the rate of growth slows and the summer growth forms cells that are darker and more closely packed. These are the DARK annual rings, the ones you count to find out the age of a tree. Because only the dark rings are counted when the age of a tree is being determined, many people erroneously believe that only one ring is formed each year.

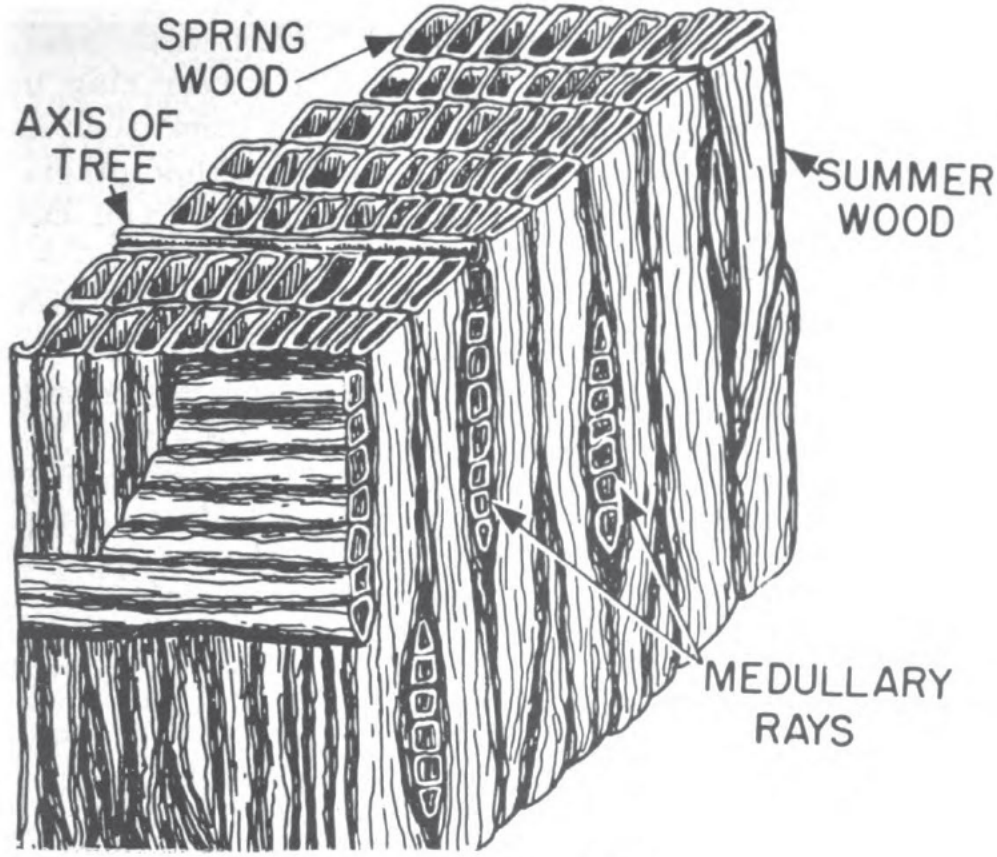


Figure 2–1.—Structure ot wood.

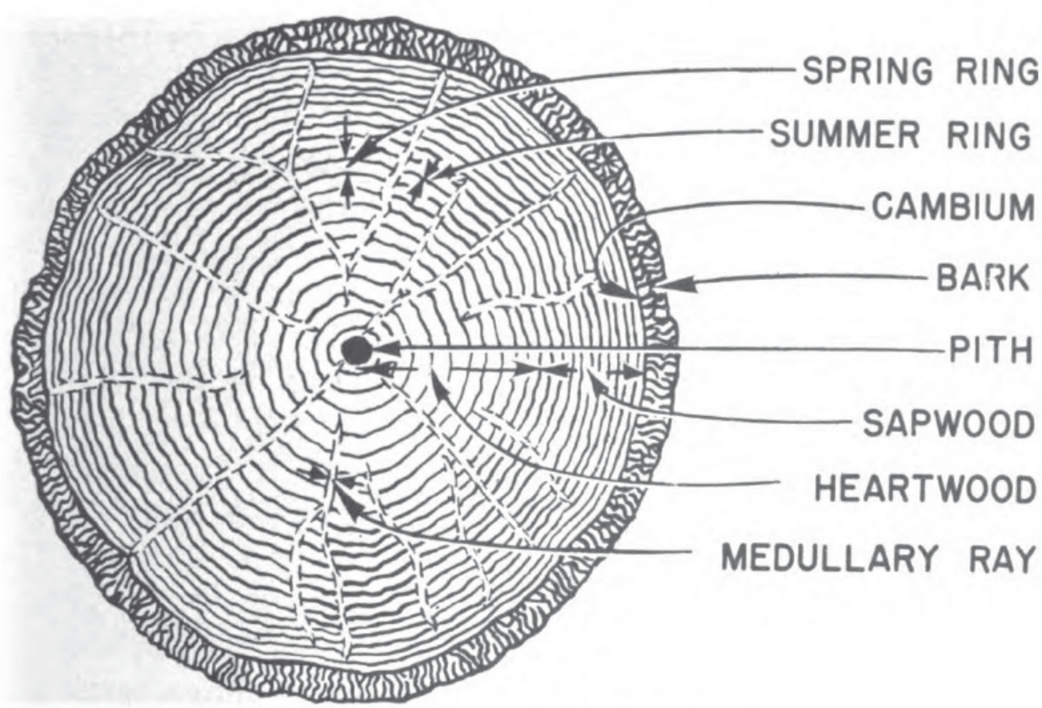


Figure 2–2.—Cross-section of a tree.

But actually two annual rings are formed each year, a light-colored ring in the spring and a darker ring in summer. Due to climatic conditions, some trees, such as oak and walnut, have more distinctive rings than others. White pine, for example, is so uniform that you can hardly distinguish the rings.

The SAPWOOD of a tree is the outer section of the tree between the HEARTWOOD (darker center wood) and the BARK. The sapwood is lighter in color than the heartwood but, as it gradually changes to heartwood on the inside and new layers are formed, it becomes darker.

The CAMBIUM LAYER is the boundary between the sapwood and the bark. It is in this thin layer that new sapwood cells form. MEDULLARY RAYS are radial lines of wood cells, especially prominent in oak. They act as dowel pins to hold the layers or rings of wood together. It requires from 9 to 35 years to transform sapwood into heartwood depending upon the type of tree.

WOOD GRAIN

A number of terms are used to describe the various grain conditions. If the cells of the wood, which form the grain, are closely packed and small, the wood is said to be FINE-GRAINED or CLOSE-GRAINED. Maple and birch are excellent examples of this type. If the cells are large, open, and porous, the wood is COARSE-GRAINED or OPEN-GRAINED as in oak, walnut, and mahogany. Furniture made of open-grained woods require the use of wood-filler to close the pores and provide a smooth outside finish.

When the wood cells and fibers are comparatively straight and parallel to the trunk of the tree, the wood is said to be STRAIGHT-GRAINED. If the grain is crooked, slanting or twisted, it is said to be CROSS-GRAINED. It is the arrangement, direction, size and color of the wood cells that give the grain of each wood its characteristic appearance.

FROM SAWLOGS TO BOARD

In a large lumber mill, such as is found in the Pacific Northwest, logs are processed into lumber with huge band and circular saws. There are two methods of sawing up logs, SLASH-CUTTING and RIFT-CUTTING. Slash-cutting is accomplished by a series of parallel cuts. If hardwoods are being cut, the process is known as PLAIN-SAWING. If

Figure 2–3.—Sailors completing repairs to a boat. Notice the distinctive grain of the cypress planking.

softwoods are being cut, the process is termed FLAT-GRAIN sawing.

Lumber that is specially cut to provide edge grain on both faces is said to be RIFT-CUT. If hardwood is being cut, the lumber is said to be QUARTER-SAWED. If softwood is being sawed, it is called EDGE-GRAIN lumber. Incidentally, if an entire log is slash-cut, several boards from near the center of the log will actually be rift-cut.

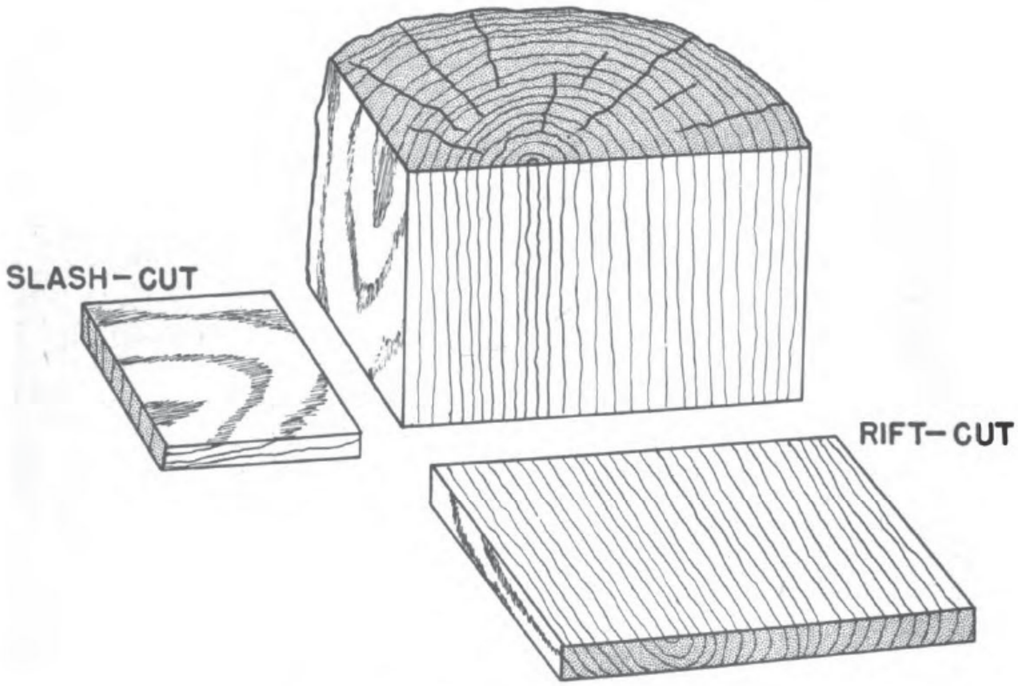


Figure 2-4.—Slash and rift-cutting.

Slash-cut lumber is usually cheaper because it takes less time to slash-cut a log, and there is less waste involved. Circular or oval knots appearing in slash-cut boards affect the strength and surface appearance much less than do spike knots which may appear in rift-cut boards. If, however, a log is sawed to produce all slash-cut lumber, more boards will contain knots than would be the case if the log were sawed to produce the maximum amount of rift-cut material. Another advantage of slash-cutting is that shakes and pitch pockets, when present, will extend through fewer boards.

For Navy decking and for all kinds of flooring, rift-cut lumber is preferred because it offers more resistance to wear than does slash-cut lumber. Rift-cut lumber also shrinks and swells less in width. Another advantage of rift-cut lumber as compared with slash-cut lumber is that it twists and cups less and does not split so badly in use. Rift-cut lumber usually holds paint better.

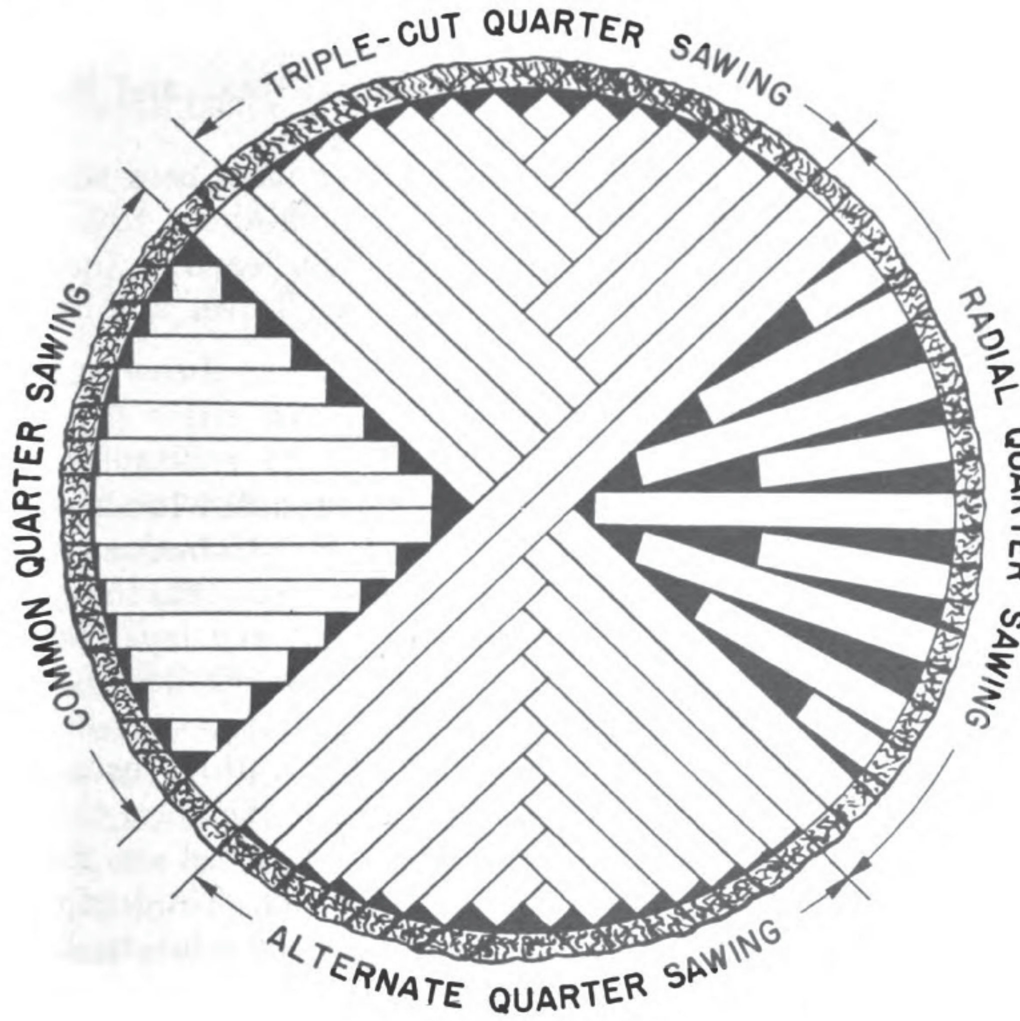


Figure 2–5.—Four methods of quarter-sawing.

SEASONING LUMBER

After lumber is sawed it must be thoroughly dried before it is suitable for most uses. The old method—and one still preferred for some uses—was merely to AIR-DRY

the lumber in a shed or stack it in the open. This method requires considerable time—up to seven years for some of the hardwoods.

A faster method is known as KILN-DRYING. The wood is placed in a tight enclosure called the kiln and treated with steam. The length of time required for drying varies from two or three days to several weeks, depending on the kind of wood, its dimensions, and the method of steaming. Often a combination of drying methods is used—the wood is air-dried from six months to a year and then finished off in a kiln.

Lumber is considered dry enough for most uses when the moisture content has been reduced to about 12% or 15%. As a user of lumber you will soon learn to judge the dryness of wood by color, weight, smell, feel, and by a visual examination of shavings and chips.

LAMINATED LUMBER

Many items today are made with laminated lumber—thin layers of wood that are glued face-to-face cross-grain. Such lumber goes by the name of VENEER, though much of it is called PLYWOOD. Actually, each layer is a sheet of veneer and the whole piece is plywood.

Plywood always has an odd number of plies—veneered stock for use in the manufacture of furniture usually having five layers. A thick layer, called the core, is in the center. Thinner, backing layers are glued on with their grains running across that of the core. The surface layers, usually of rare and expensive facing veneers, are placed so that their grains parallel the grain of the core.

Ordinary ¼″ and ⅛″ plywood has only 3 plies. Thicker plywood may have as many as fifteen plies—but always an odd number. The standard size of plywood sheets is 4 feet wide by 6 to 12 feet long, though smaller and larger sizes are available.

Plywood is an excellent material for paneling, and for making counters, desks and chairs. It is available in

sheets large enough for use in ceilings and sidewalls. The cheaper grades of plywood are frequently used for making shipping cases, boxes and concrete forms. This laminated wood is fastened by nails or screws. However, you should not plan a job which requires nailing into the edge or end of plywood.

The development of special glues and other bonding materials has made possible a WATERPROOF plywood. It found wide use during World War II in the construction of crash boats, PT boats, and landing craft.

GRADES AND SIZES OF LUMBER

Softwoods, particularly those used for construction, are usually cut to standard thicknesses, widths and lengths. Hardwoods to be used for cabinet, furniture, and other finish work, are usually cut to specified thickness (in graduations of ¼ inch), and to random widths and lengths with specified minimums. Walnut lumber, for example, might be bought on the condition that all boards be 4 inches or wider and 6 feet or longer. Hardwoods used for construction, such as oak, are usually cut to all standard dimensions.

Lumber pieces that are less than 2 inches in thickness are usually called BOARDS. Pieces from 2 to 5 inches in thickness are called PLANKS or DIMENSION LUMBER. Heavier pieces are known as TIMBERS. Pieces of lumber used in construction are also named according to use. Such pieces are known as SILLS, JOISTS, BEAMS, RISERS, STUDS, and RAFTERS.

Softwoods are graded as SELECT (interior finish lumber) or COMMON. Select lumber is further graded A, B, C, and D; common is graded 1, 2, 3, and 4. Much of the lumber used for building houses is No. 2 or No. 3 common. Grades are based on the kind and size of defects, size of the pieces, and seasoning condition. If you buy

MILL RUN lumber you take everything that is sawed except the slabs (bark).

The size of lumber is usually figured as the ROUGH-SAWED dimensions. Lumber that is DRESSED (planed or surfaced) is either surfaced to a specified size or to maximum thickness. If lumber is dressed on two opposite surfaces it is designated by the symbol "S2S." If it is surfaced on all four sides the symbol is "S4S."

Plywood is usually furnished with sanded surfaces. Plywood with both faces clear is indicated by the symbol "G2S," this means "good on two sides." Some plywood may have defects or be patched on one face in which case it will be designated "G1S"—good on one side. For many uses, particularly when one side is not going to be visible when the plywood is installed, G1S is just as satisfactory as G2S.

LUMBER MEASURE

The standard measure for lumber is a BOARD FOOT, which is one INCH thick, one FOOT wide, and one FOOT long. It's one-twelfth of a cubic foot and may take different shapes, as shown in figure 2–6. Figuring the number of board feet in a piece of lumber is easy if you know the formula and can work simple arithmetic problems involving fractions. There are several formulas you can use. Here's an easy one:

BOARD FEET equals the thickness of the board expressed in inches multiplied by the width expressed in feet, and the length expressed in feet.

$$(T'' \times W' \times L' = B.F.)$$

Suppose you want to determine the number of board feet in a piece with dimensions 2″ × 6″ × 12″? Use the formula and work it like this—

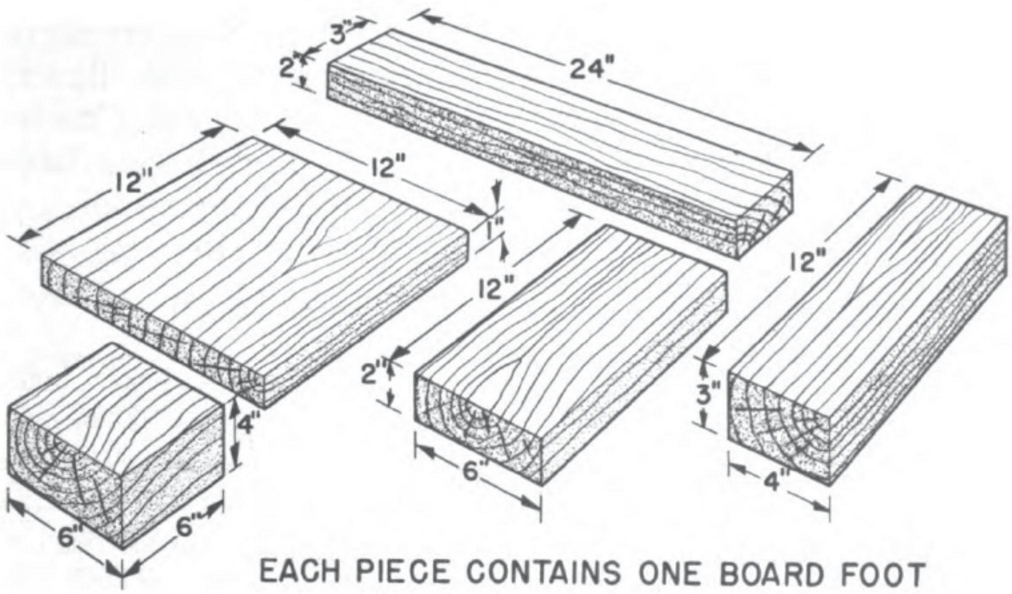


Figure 2–6.—The board foot.

$$T'' \times W' \times L' = B.F.$$

$$\frac{2}{1} \times \frac{6}{12} \times \frac{12}{12} = 1 \text{ B.F.}$$

or

$$\frac{2}{1} \times \frac{1}{2} \times \frac{1}{1} = 1 \text{ B.F.}$$

Now, how would you find the number of board feet in a piece that is $4\frac{1}{2}'' \times 10'' \times 14'$? And the answer—

$$T'' \times W' \times L' = B.F.$$

$$\frac{9}{2} \times \frac{10}{12} \times \frac{14}{1} = \frac{105}{2} = 52.5 \text{ B.F.}$$

Boards under one inch in thickness are considered to be 1 inch thick unless otherwise specified.

Plywood is ordinarily ordered and sold by the SQUARE FOOT. Specially manufactured or milled lumber, such as narrow battens and moldings, are sold by the LINEAR FOOT (running foot). Flooring lumber for shore buildings may be sold by the board foot but some is sold and figured according to the area (square feet) of floor it will cover.

Lumber must be stacked or stowed so that it will remain dry and will not shrink, expand or warp excessively. A lumber stack or pile should be well ventilated and adequate supports provided so that the weight of the wood will not cause sagging between supports. See figure 2–7 in reference to the incorrect storage of lumber.

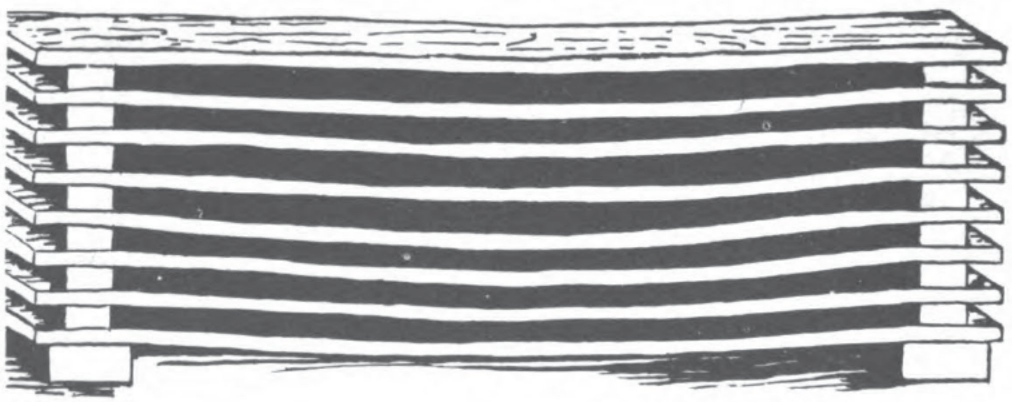


Figure 2–7.—Lumber incorrectly supported in storage (note sagging).

The supports placed between lumber are termed "scantlings" in the Navy. Each layer of lumber should be separated by scantlings and these supports should be laid down in line, and level. (See figure 2–8 for the correct

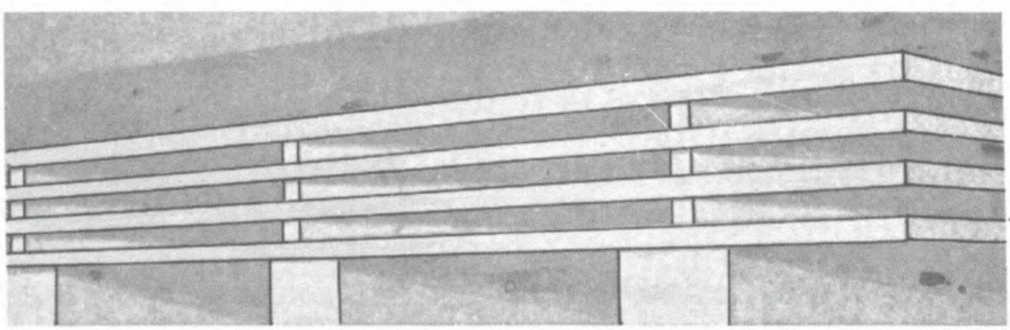


Figure 2–8.—Correct storage arrangement for lumber.

storage arrangement for lumber.) Two sizes of lumber should never be stored in the same stack of material. It is not necessary to separate kiln dried lumber by scantlings. However, when such lumber is piled higher

than the base width, supports should be utilized in order to tie the pile together. Lumber stacked on the outside should always be protected from foul weather by waterproof canvas coverings. Timbers should be placed for the foundation of an outside lumber stack in such a way that the lumber pile will be on a slight incline. Then

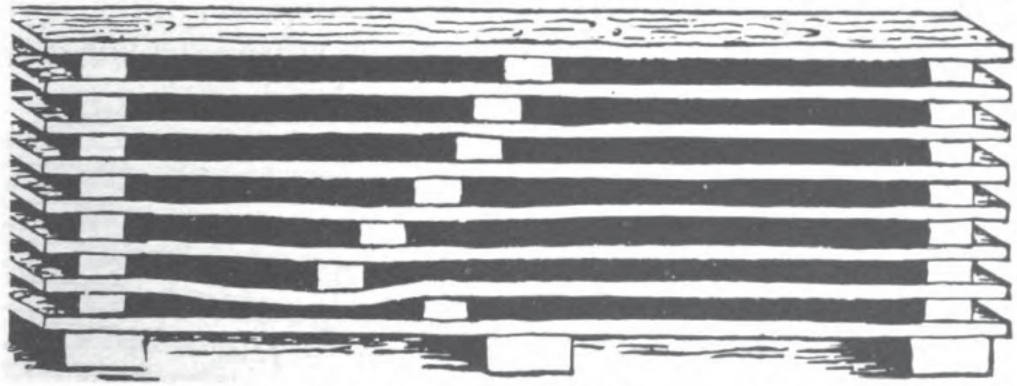


Figure 2–9.—Lumber carelessly supported.

during rains the water will easily flow off. (See figure 2–10. Outside Lumber Pile.)

Figure 2–10.—Outside lumber pile.

LUMBER DEFECTS

You will seldom find a piece of lumber that doesn't have defects of some sort. Some defects are a result of the way the tree grew in the forest. Some are the result of

inadequate or improper seasoning. Still others are caused by careless milling processes and handling. Bugs, worms, and borers contribute defects, both before and after the lumber is cut. And occasionally you'll see a chunk of lead imbedded in a board, probably indicating that some north woods hunter took a shot at a running deer and missed. Then add the horse shoes, chains, and pieces of "barb" wire and clothesline that are sometimes found in lumber and you'll see why sawmill operators have nightmares.

Figure 2–11.—Defects of logs.

Probably the most common defects are KNOTS, which occur in almost all kinds of lumber and are the result of branch growth. An ENCASED knot is formed when a branch dies and is completely surrounded by new tree growth. Such knots are usually decayed and loose. An INTERGROWN knot has its annual rings interwoven with those of the tree trunk and is usually solid enough so that it does not constitute a serious defect. A SPIKE knot is a long thin knot.

Small solid knots are not objectionable in most of the lumber used, but lumber containing loose or large knots should be culled or cut up into smaller pieces.

A SHAKE is a place where the wood is separated between the annual rings during tree growth by the action of the wind. A CHECK is a crack or separation, usually short, that is caused by unequal shrinkage during seasoning.

DECAYED WOOD is said to be "DOTY," "DOZY," or rotten. Creosote and zinc chloride preservatives are applied to some woods to prevent decay. Small enclosed spaces in the wood that are filled with bark or pitch are called PITCH POCKETS.

You're probably already familiar with WORM HOLES, especially the pin-size kind. They seldom constitute serious defects in rough construction but are undesirable when natural finishes are used.

WARP is any condition in which a piece is out of line—twisted, bowed, or cupped. A board that has WANE is one that is not full or true size—one that lacks wood along corners, edges, or ends or is partially composed of bark.

FIBER BUILDING BOARDS

Fiber building boards have risen to a position of great importance among the materials used in the building industry, particularly for prefabricated structures and renovation. The two main classes of fiber building boards are "wall boards" and "insulating boards." In wartime construction, wall board was used in great quantities because of its low cost and the ease and speed of its application. Also, fiber insulating board has come into extensive use in construction work. These boards are manufactured lumber for definite applications in building construction.

Wall boards are made for use as wall, ceiling, and partition finish on the interiors of buildings, while insulating boards are made for use as insulation within walls, partitions and roofs of buildings. Wall boards are often made so as to have a surface suitable for interior finish, therefore, the two classes overlap to some extent. The strength of both classes of boards are the same and the types in common use are the laminated type and the homogeneous type. The laminated product consists of several sheets of thin fiber pasted together while the

homogeneous product is a one-piece moulded product. Fiber boards, especially the homogeneous type, are used for a variety of purposes, such as a base for inside plaster and outside stucco, for sound deadening, and for improvement of acoustics in auditoriums and radio broadcasting studios.

QUIZ

1. Name the woods which you'll use for building framing.
2. Why is white pine (soft pine) one of the patternmaker's favorites?
3. Name three of the woods you'll use in building trim.
4. Name three of the uses of white pine in carpentry.
5. What are some of the uses of basswood?
6. Why is chestnut used mainly for poles and fence posts?
7. What is the best material for making tool handles?
8. Name three woods that are used for cabinetmaking.
9. Why is cypress used for doors, porch materials, water tanks and siding?
10. White cedar is not strong enough for building construction but it has many uses because of its good weather resistance. Name two of its uses.
11. Rungs of most of the ladders used in construction work are made from what wood?
12. What is the best hardwood obtainable for making furniture and boats?
13. What is the sapwood of a tree?
14. What is the cambium layer of a tree?
15. What is the faster method of thoroughly drying wood called?
16. As a user of lumber how will you soon learn to judge the dryness of wood?
17. How are softwoods graded?
18. Plywood with both faces clear is indicated by the symbol "G2S". What does this symbol mean?
19. What is the standard measure for lumber?
20. What are the supports placed between lumber called in the Navy?
21. What causes the most common defects in lumber?
22. Name the two main classes of fiber building boards.

CHAPTER 3

SURFACE PREPARATION FOR PAINTING

A GOOD BUILDER—A GOOD WOODWORKER

The mirror-like surface of a grand piano, or the satin smooth finish of a natural wood panel in your favorite night club is an example of what can be done with wood when the surface is properly prepared to receive finish.

You may never build a grand piano, but you will be preparing wood surfaces for painting and varnishing.

Before wood as a raw material can become a building material, it must be grooved, planed, sanded, sawed, or otherwise manufactured into various sizes, shapes, and forms. Over 5,000 standard usable stock items are manufactured from wood, and it is with these that the Navy and private industry builds everything from baskets to barracks.

There are many types of wooden surfaces and each has its place, but in fine work the difference in the finished surface will determine whether the workman is a "wood-butcher" or a cabinet maker.

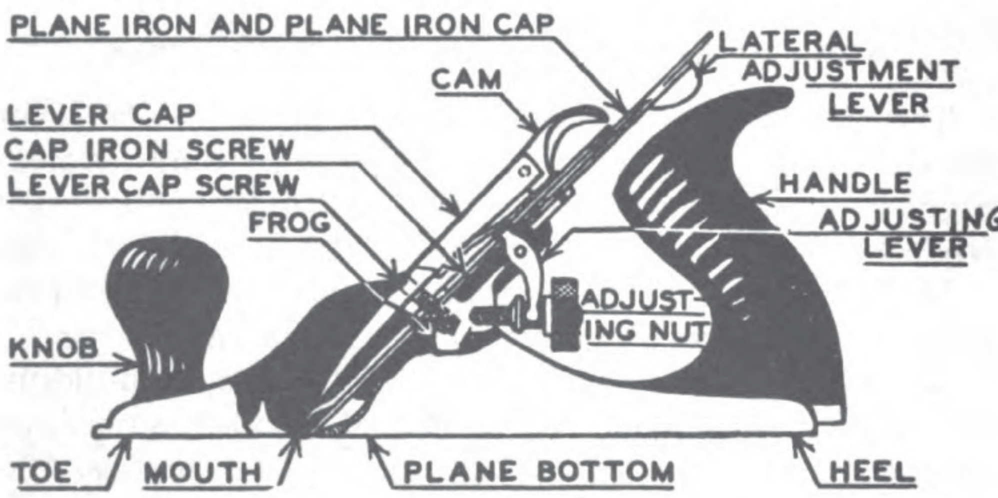
Woodworking, woodfinishing, and construction are all branches of the builder's craft. The builder who puts thought and feeling into every movement of his hands will find a real pleasure in turning out a job that will emphasize his skill and craftsmanship. You can pretty well tell whether a man is an A-1 builder when you look at the finishing touches on a job he has done.

PREPARING WOODEN SURFACES

Lumber, which you'll handle in building jobs, comes from the sawmill in a very rough state. Before it becomes finished work, it must be prepared for the application of paint, varnish, or other kind of wood preservative. This preparation consists of PLANING, SCRAPING, and SANDPAPERING.

PLANING

There are many kinds and types of planes used to prepare lumber; however, the principles of all of them are

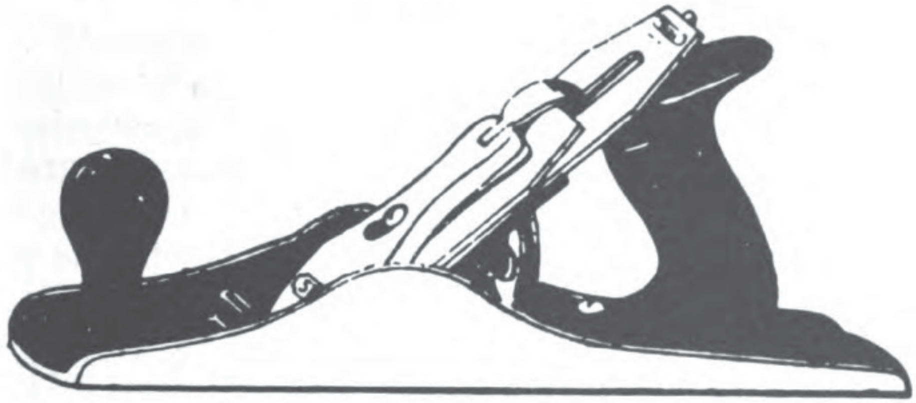


Courtesy of Delmar Publishers.

Figure 3–1.—Parts of a plane.

fundamentally the same. The various parts of a plane are shown in figure 3–1.

There are three types of planes which are used most frequently by the builder. These are the JACK PLANE, SMOOTH PLANE, and the BLOCK PLANE.



Courtesy of Delmar Publishers.

Figure 3–2.—The jack plane.

The JACK PLANE shown in figure 3–2 is used for smoothing rough surfaces and planing boards to size and squareness. With this plane you'll make the direction of cut WITH the grain of the wood.

The jack plane is usually 14 inches in length, with about a 2-inch cutter or plane iron. Frequently the plane iron is ground so as to give it a slightly convex edge. This convex edge enables you to do a fast job of smoothing a rough surface.

Courtesy of Delmar Publishers.

Figure 3–3.—The smooth plane.

The SMOOTH PLANE is similar to the jack plane but is only 9 or 10 inches long. It is used for fine work on small pieces of stock. The cutter is generally sharpened straight across, with the corners slightly rounded so that the plane will cut very evenly. These planes come in various sizes, but the 9-inch plane with the 2-inch cutter illustrated in figure 3–3 is the type that you'll use most often.

The BLOCK PLANE is the smallest of the planes in your kit. You'll use the block plane in trimming end grain to make close fitting joints. This tool is manufactured in various sizes from 3½ to 7 inches long. The size generally used is 6 inches long with a cutter 1⅝ inches wide. Figure 3–4 shows a plane of this type.

Courtesy of Delmar Publishers.

Figure 3–4.—The block plane.

In planing the end of a board, lift the block plane before the end of the cut (see figure 3–5) to avoid splitting the board at the edge. Work from alternate ends, taking a few cuts at a time from each direction. For further information on the adjustment of planes and the sharpening of plane irons, review your *Basic Hand Tool Skills,* NavPers 10085.

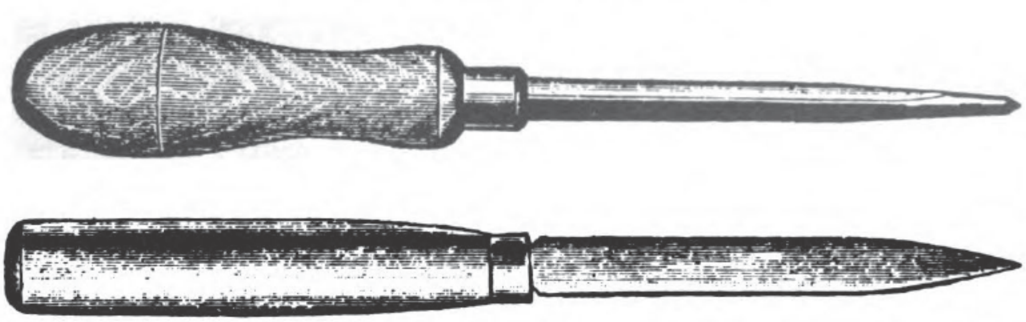
SCRAPING

To make flat planed surfaces even smoother, your best bet is a SCRAPER. Use the scraper just after planing

and just before sandpapering. It's easier to smooth curly- or wavy-grained wood with a hand scraper than with a plane.

A HAND SCRAPER is made of tool steel. There are two general types—one has a single chiseling edge plus a handle; the other has two chiseling edges, one at each end. There are several types of chiseling edges also. The triangular scraper is probably the most popular, and can be used on practically any flat surface. Oval and oblong scrapers are used on concave surfaces and moldings.

Figure 3–5.—Block planing across grain.



Courtesy of Theo. Audel & Co.

Figure 3–6.—Burnishers—round and oval-shape blades.

The BURNISHER (see figure 3–6) has an oval-shaped blade or a round blade about 4 inches long. The edge of the scraper is cut square with a file, then one or more edges are turned over slightly with the burnisher. This turned-over edge, known as the hook, is the scraping edge of the hand scraper. You'll be able to regulate the cut of the scraper by the "hook" or the amount turned over with the

burnisher. A greater hook will cut more rapidly, but the smoothest wooden surfaces are made with only a slight hook on the scraper.

You'll be able to remove mill marks and to smooth surfaces easily, if the scraper blades are properly sharpened and the scraper properly handled. When cutting with the scraper, you should always incline the tool slightly in the direction of the cut. You'll find it best to scrape WITH the grain of the wood. Use an even pressure and as long a stroke as possible. When you bring the scraper back into position, always lift it from the material.

THE "CLEANUP"

The next step in preparing a surface is known as a "cleanup." Wood to be finished in natural or stained color must be thoroughly prepared before the application of varnish or stain. The surface must be dusted off with a duster, or in the case of floors, with a brush or a broom. All spots of plaster, dirt, or grease should be removed. Usually such spots will come off by washing with any cleaning compound. Use a putty knife to scrape off as much as possible, then wash off with a cleaning compound. Any paint cleaner may be used, but do not use alkaline solutions such as lye or trisodium phosphate. If oil and grease spots are still evident, follow the washing operation by wiping with paint thinner. Be sure to wash the surface after using paint thinner.

Steel wool can be used on shellacked or varnished surfaces, but not on other surfaces because small steel particles will break off and cause rust spots to form. Never use steel brushes on any wooden surface as they will mar and scratch. If the wood is oak, walnut, or any of the other open-grained varieties, you should use particular care in removing dirt, lime, and grease from the pores of the wood. Surfaces which are to be painted or enameled should be cleaned well and loose particles on the surface removed. When the surface is thoroughly clean and dry, it is ready to be sandpapered.

PAINT REMOVER

As you know, you will also have old painted surfaces to prepare for a new paint job. Preparation of these surfaces includes paint removers, burning off, sandpapering, or blast cleaning.

You can use paint and varnish removers if they can be utilized efficiently to clean both interior and exterior surfaces. Paint removers consist of organic solvents with retarders of evaporation. Apply the remover liberally with a full brush without brushing out any more than is necessary. Do not break the wax film which forms over the remover after it has been applied, because this would allow the gases to escape without acting on the paint film. Due to the toxic nature of the volatiles in paint remover, adequate ventilation is necessary.

Let the remover stand until the old paint or varnish begins to blister or wrinkle. This takes from ten to twenty minutes, depending upon the type and thickness of the old finish. After the old finish begins to wrinkle or blister, lift it off with a broad putty knife or hand scraper. Apply another coat of remover and with steel wool rub in the direction of the grain, removing any last traces of the old finish. Wash the surface with paint thinner or alcohol to get rid of any wax or acids left by the remover. Soap and water may be used but water tends to darken the wood and causes the grain to raise.

Paint remover will work faster and better on horizontal surfaces. Doors and other pieces which can be removed should be placed in a horizontal position on a bench or sawhorse to facilitate the operation. Sand to obtain a fine smooth surface. The surface must be thoroughly dry before applying paint, varnish, or lacquer.

BURNING OFF

It may become necessary to remove old paint from wooden surfaces by burning it off. If a sandblaster is on hand, it is preferable to play it safe and use it, since

burning and scraping meet with disapproval because of the fire risk. However, it is wise for you to know how to remove old paint with a torch. The exercise of ordinary care and common sense is all that is necessary to make it safe. Exterior surfaces, which need repainting because of alligatoring, checking, cracking, flaking, scaling, or excessively built up thickness, can be easily removed by burning.

For tools, you'll need a gasoline torch (usually a one-quart torch is large enough, scrapers, a bucket of water, and a syringe. The last two are necessary because occasionally hot scrapings or the torch flame will start small fires in places that are difficult to reach. In that case, your best extinguisher is a large syringe.

The technique is to blister the paint with the torch without scorching the wood, and then to scrape off the charred paint with a hand scraper while it is hot and soft. This appears difficult, but you can acquire this skill with a little practice.

Hold the torch by the body during the operation. In that way you will know if the torch begins to overheat. This is very important because overheating of the torch might result in an explosion or rupture. The greatest amount of heat is always directly above the flame. Start burning off paint from the lowest point and work your way up. The flame should be held in one spot only long enough to blister the paint. With practice, you'll learn how to use the torch in one hand and follow through with a swift coordinated action of the scraper with the other hand.

A good job of burning off will show a surface reasonably free from scorches and the paint so completely removed that only a slight sandpaper rub will be necessary before painting.

PLASTIC WOOD AND PUTTY

After planing wooden surfaces smooth, use plastic wood to fill cracks and holes where any strength is required.

Plastic wood may be stained to match the color of the wood. When dry, you can bore, cut, ream, saw, and drive nails into plastic wood.

You can use putty where no strength is required. Whiting is used primarily for preparing putty of good adhesive elastic and ductile properties in the following ratios by weight: 8½ parts whiting, 1 part white lead paste, and 1½ parts raw linseed oil. The larger the proportion of white lead, the more durable and hard will be the putty.

Glazing putty is a composition of a large proportion of whiting mixed with boiled linseed oil, with just enough white lead to make it harden into a durable mass. Calking putty for boats consists of white lead, with just enough whiting to keep it from sticking to your hands.

You can color putty by adding a little paint, or a little ground color mixed with drier. Putty is waterproof, shrinks very little, and you can push it into depressions easily. Never apply putty to bare wooden surfaces. The wood will absorb the oil in the putty. Mix putty on glass or metal.

SANDPAPERING

Your next step consists of sandpapering the surfaces. The perfect finished job must always be well sandpapered. Sandpaper consists of tough paper covered with finely crushed abrasive material.

Broadly speaking, sandpapers can be divided into two types—those that use natural abrasives, and those that use artificial abrasives. The flint and garnet grits of ordinary sandpapers are natural abrasives; that is, they are used in the same form as taken from the ground. So are emery and corundum, which are used in the production of some grades of abrasive sheets. It is interesting to note that sea sand is never used, as the sharp edges have been worn dull.

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Sandpaper is made on paper especially prepared from old manila rope which produces paper of the greatest strength. Many old and worn manila lines that were used on naval ships have been used to make strong paper to be used in manufacturing sandpaper. In order to test sandpaper for quality, rub two sanded sides together; if the sand comes off easily, it is poor stock.

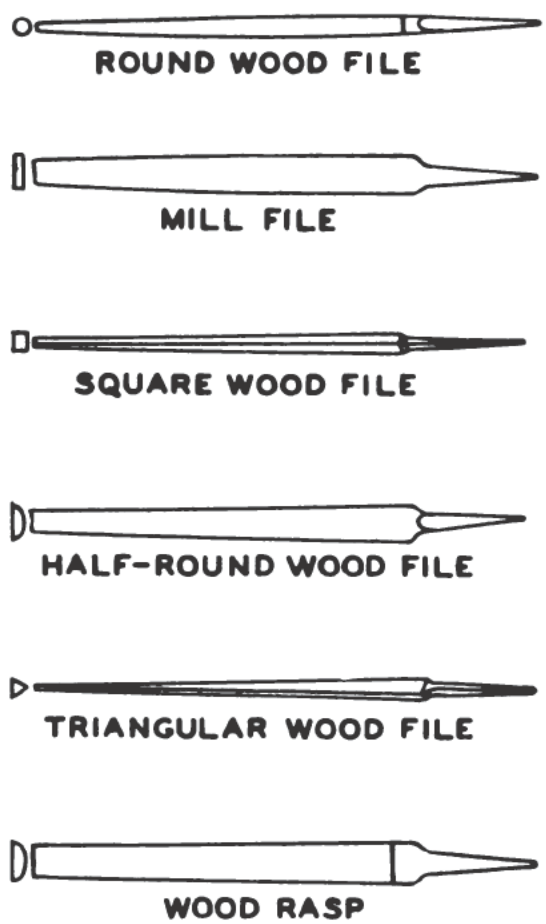
Artificial abrasives have largely replaced natural abrasives for use on metal. The two principal artificial abrasives are silicon carbide and aluminum oxide.

The size of an abrasive is indicated by its code number. These numbers range from 4 to 5/0. In garnet and artificial abrasives, 2½ to 1½ is coarse; 1 to 0 is medium; and 2/0 to 5/0 is fine. In flint paper or emery cloth, 3 to 2 is coarse; 1½ to ½ is medium; and 0 to 3/0 is fine. The grits of artificial abrasives are also known by the numbers 120, 100, 90, 70, etc., from fine to coarse which represents the number of meshes per inch of screens through which the grains will pass.

The usual procedure in sandpapering is to go over the surface first with a coarse sandpaper, then polish it with one of the finer grades. You should examine the surfaces of the wood to be sanded in order to detect any necessary additional smoothing needed with the plane or scraper. Always bear in mind that sandpaper is not a substitute for edged tools and should not be used until the cutting operations are completed. The cleaning necessary after sandpapering should be done with a duster brush. On fine cabinet work in particular, you should use every effort to remove every particle of dust. When sandpapering, you should hold the sandpaper quite flat against the wooden surface and rub evenly up and down with as long sweeps as possible, taking care to rub in the direction of the grain. Never attempt to rub across the grain. Do not bear hard upon the edges of the wood or they will be ground off.

RASP and FILES are handy tools with which to smooth and round edges and curves. When you are filing wooden or metal material, as you draw the file back between the cuts, you should not allow the file to drag. The file may be injured more in this manner than when you are actually cutting material. In using large files or rasps secure the material firmly in a vise, so you can use both hands in the filing operation. Grasp the handle of the tool with one hand while pressing, not too heavily, near the end of the file, with the other.

A variety of shapes, round, flat, square, half round, and triangular, are used. Figure 3–7 illustrates several types



Courtesy of Delmar Publishers.

Figure 3–7.—Types of files.

of files. Files range in length from 4 to 14 inches. The teeth of a file vary in degree of fineness.

The teeth's spacing, and the angle at which the teeth cross the surface, are termed "the cut of the file." Single-cut files have teeth running in parallel lines diagonally across the surface. Double-cut files have a double series of teeth crossing each other at an angle. Both single- and double-cut files commonly are made in 4 degrees of coarseness, rough and bastard for rough, fast work; second-cut for tough alloys and more finished work; and smooth-cut for a fine, smooth finish. Rasps have very coarse teeth and are made for rough work and where it is necessary to remove considerable stock before you use a wood file. Never use a file or a rasp unless it is equipped with a handle of the correct size.

MASONRY SURFACES

Now that you are squared away on the materials and tools used to prepare wooden surfaces for painting, let's move on to the preparation of masonry surfaces. Here, too, it is necessary that you be familiar with the materials and tools with which masonry surfaces are prepared for painting.

As you know, masonry sidewalls consist of brick, cinder and concrete block, concrete, stone, stucco, terra cotta, and various combinations of these materials. Generally, masonry sidewalls are made watertight by coating the exterior surfaces with cement mortar.

Masonry surfaces will not be painted unless it is necessary for dampproofing. If masonry surfaces already are painted, they may be repainted with the same type of paint as exists on the surface, unless it is in such bad condition that it warrants complete removal.

SURFACE PREPARATION

Masonry surfaces must be completely clean and free of efflorescence, grease, and other foreign matter. Efflo-

rescence is a powdery crust on the walls that is easily removed by wetting with a solution of water and 5 to 10 percent muriatic acid. After five minutes, the salt deposits can be scoured off with a stiff brush. After each such treatment the surface must be washed promptly and thoroughly with a liberal amount of water.

BLAST CLEANING

Where old surfaces must be removed, blast cleaning is considered the most satisfactory method of obtaining a clean surface for painting. In the past, however, wet or dry sandblasting has been restricted to naval shipyards because of the size of the sandblasting equipment and the necessity of using great amounts of abrasives. Lately, a small vacu-blaster (figure 3–8) which has been developed is replacing the large sandblasting equipment. The operating cycle of the vacu-blaster is as follows: compressed air forces the abrasive from the hopper through a supply hose to the blast nozzle and inner cone of the gun; the vacuum system picks up the cleanings and spent abrasive and returns them to a reclaimer. Here the abrasive is air washed to remove foreign matter. The washed abrasive is then returned to the hopper for further use. The separated foreign matter is drawn through a hose to a dust collector where it is retained for disposal.

Traces of oil can be removed with steel brushes, abrasive stones, or a lye solution. When the surface is generally contaminated by oil, it should be sandblasted lightly, if the abrasion will not damage the surface. Very smooth, nonabsorbent or glazed surfaces should be washed with an acid solution, sandblasted lightly, or rubbed with coarse abrasive stones. Scaling, flaking, peeling paints, or whitewash, must be completely removed. In general, when surfaces have been treated with materials that are known as colorless waterproofing compounds, it is necessary to remove all this material from the surfaces and pores before any paint is applied.

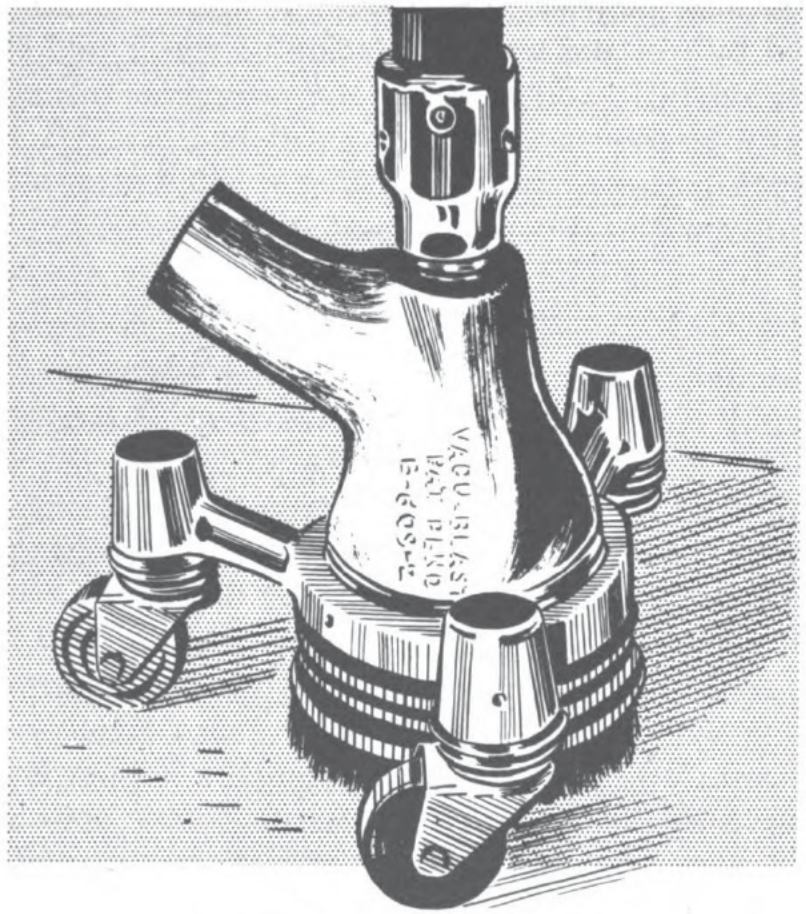


Figure 3–8.—The vacu-blaster.

Except when cement-water paint or alkyd-resin-emulsion exterior paint is to be used, previously unpainted surfaces should be given a zinc-sulphate neutralizing treatment. The solution should be removed immediately after each washing by a liberal application of clear water. Surfaces to which cement-water paint is to be applied should be drenched thoroughly and uniformly with clear water several hours prior to painting and then dampened again with fog spray immediately before the paint is applied. Free water should not be permitted to stand on the surface. A solution of 2 pounds of zinc-sulphate dissolved in 1 gallon of water should be used for cement asbestos board, and 3 pounds of zinc-sulphate dissolved in 1 gallon of water for other masonry surfaces.

PRETREATMENT OF MASONRY SURFACES

As we have mentioned above, cement-water paints require thorough wetting down of the surface prior to painting. The wall should be damp but not dripping wet when the paint is applied. If the surface dries rapidly, as it may in hot weather, it should be re-dampened slightly just before painting. Never apply cement-water paints on surfaces painted with oil-type paint. Cement-water paints require no priming prior to application.

Oil paints require dry surfaces. The application of oil paint to new masonry should be deferred until the walls have had time to dry. Leaks around flashing of doors and windows should be repaired to exclude moisture before the application of oil paint. At least 1 week of clear, dry weather should precede the application of the first coat of oil paint to masonry. Since masonry surfaces tend to chill and collect condensed moisture, do not apply oil paint early in the morning or late afternoon unless you are in a dry climate. Unpainted surfaces that are to receive interior flat oil paint or gloss enamel should be given a coat of oil-type pigmented sealer of the controlled penetration type.

REPAIRING MASONRY SURFACES

Before applying paint the clean surface must be given a thorough going over to patch any mortar which is in bad condition. Chip and pick out loose mortar between masonry courses; then brush the joint thoroughly to remove all dust and loose particles. Clean the surface again before applying new mortar to prevent absorption of water from the mixture.

The proportion of sand to cement depends entirely upon conditions, a larger proportion of cement being necessary where excessive moisture prevails. To make ordinary repairs use a mixture of 1 part cement to 2½ parts sand. For damp basements or exposed masonry use a 1:2 mix-

ture. Enough water should be used to make a fairly dry mortar, about the consistency of putty. It should be thoroughly mixed and worked to ensure best results in filling cracks. The mortar should be used like calking material, that is, it should be well tamped to form a complete bond. When the crack has been tightly packed, the surface should be smoothed with a trowel. In pointing up joints in masonry, apply the mortar with a trowel and finish the surface to conform to the old mortar.

PREPARING PLASTER SURFACES

You know that there are two ways to do a job—the right way and the wrong way. This is especially true when preparing plaster surfaces for painting. The first requirement of a good plaster surface is that it be perfectly smooth. You will rarely find it in this condition. New plaster will have splashes of mortar which you must remove with a wide scraper. The rough places must be smoothed with No. 0 sandpaper. Care must be taken not to cut through the glazed plaster surface as suction spots will result.

If you want a good appearance, utmost care must be taken to fill all cracks. The first operation consists of cutting the cracks open. Use a putty knife, holding it firmly at the lower end of the blade. Cut the crack in the form of the letter "V" with the wider part on the inside and the narrow part on the surface. This is an important operation as it prevents the plaster filling from sagging or falling out.

Old, firmly adhering plaster, adjacent to the openings should be wetted down to prevent the absorption of water from the new plaster. Fill the openings with plaster of paris, or spackling, which you can conveniently mix in a shallow pan. Place water in the pan and sprinkle plaster of paris or spackling over it, allowing it to soak up the water. Plaster of paris and spackling set quickly; therefore, do not mix more than you can use in 10 minutes.

Pick up the mixture with your broad scraper and place it in the palm of your hand. While it is in your hand, turn it over with the scraper once or twice, in order to wet any portions that have not absorbed water. Press it into the crack. When you have filled the opening to a point about ⅛ inch from the surface, let it set while you fill other cracks. Go back and apply additional plaster to the first spot, then finish it off level with the surface. In about seven days, sandpaper the new plaster until smooth.

Old plaster surfaces sometimes contain very fine cracks which are too fine to be filled with plaster. You will frequently hear these fine cracks referred to as fire, or hair-line cracks. One method used to fill these cracks consists of brushing with linseed oil containing a little turpentine and drier. Another method consists of applying a coat of glue size after the first coat of paint has dried. Glue size is used in this method in order to save paint. An additional coat of paint would accomplish the same result.

Before applying paints to plaster, ample time must be allowed for the plaster to set and dry. Always allow newly plastered surfaces to remain unpainted for several months. As you know, there is calcium hydroxide (hydrated lime) in plaster. In time, this combines with the carbon dioxide in the air. Unless this process is complete, the lime will react with the oil in the paint. In order to prevent this reaction, brush the new plaster with a wash, consisting of two pounds of zinc-sulphate dissolved in ½ gallon of water. Make sure that the wash is thoroughly dry before applying paint. This wash is not necessary when you use paints with a water or rubber base. Patches of fresh plaster from the repairing of cracks must be shellacked, followed by two coats of flat paint. If these two coats are applied, glossy or shiny spots will not appear in the finished coat.

After repairing plaster defects, ceilings and sidewalls are prepared for water-based paints by applying a coat of shellac or sealing varnish. This ensures a uniform

finish free from flat patches. It also simplifies the application of water-based paints by permitting a freer flow over the glazed surface.

METAL SURFACES

Suppose you have been assigned to paint metal surfaces. If you want the paint to adhere to metal, make certain that you have a clean, dry surface. New metal must also be free from resin (soldering flux), oil, and grease. Here you need an application of an organic solvent such as benzine or turpentine. You will usually find old metal more or less rusty and with considerable loose and scaling paint. Clean thoroughly by using a scraper and wire brush.

When the job at hand calls for painting galvanized iron, remember that it has a zinc coating to protect it from rust. Zinc repels paint; therefore, you must first roughen the surface of galvanized iron so that the paint will adhere to it. For this purpose, wet it down with a solution containing two ounces of copper chloride and two ounces of ammonium chloride in one gallon of water. Rub the metal surface thoroughly with steel wool after the solution has been applied.

You will find that red lead is the best all-purpose, protective paint for metal, especially for iron or steel. Formulae for red lead paint will be given in the next chapter. It is widely used for the first priming coat. It can be followed by a coat of the color you desire.

PAINT FAILURES

A good guide in preparing painted surfaces for repainting will be your knowledge of the causes of the following paint failures:

1. Alligatoring and checking
2. Bleeding
3. Blistering

4. Chalking
5. Crawling or creeping
6. Dirt collection
7. Fading of color
8. Flaking, cracking, and scaling
9. Gas discoloration
10. Loss of gloss
11. Mildew
12. Peeling
13. Running and sagging
14. Suction spotting
15. Tackiness and slow drying
16. Washing
17. Wrinkling

Alligatoring and Checking

Alligatoring and checking of a paint film exists when the outer layer of paint cracks and presents a pattern similar to alligator leather. This condition occurs when relatively hard finishing coats of paint are applied over relatively soft priming coats. Under coats, which are too rich in oil or have been allowed insufficient drying time, cause this softness. Expansion and contraction of the painted surface where paint coats have unequal flexibility because of soft undercoats and hard outer coats causes alligatoring and checking. Remember, to avoid this failure, always allow undercoats to dry sufficiently hard before you apply the next coat. Do not add too much oil to priming materials. In most cases, to remedy alligatoring, you must remove the paint with a torch and scraper. Painting over alligatored surfaces will result in an unsightly finish and possible rupturing of the new paint. In some cases, you can remedy this condition by scraping and wirebrushing all loose scale, and then sanding to a smooth surface before painting.

Painting over knots or other resinous wood causes a dissolving action of some of the resin. As a result, light

color paint turns yellowish. Painting over creosote, bitumen, or colors soluble in oil (mahogany stain, for example) likewise may cause some of the material to dissolve into the paint film. The remedy for these conditions is to treat the surface to be painted with a sealer prior to applying the paint. "Sealer, knot" is a good sealer for this purpose.

Blistering

Blistering is a term applied to a paint failure where large blisters appear in the paint film. Usually, you will find the top coat lifting and leaving the prime coat intact. This condition is the result of moisture being absorbed by the wood. Your inspection of the structure may indicate that the moisture is coming from a steamy galley or head, leaks in plumbing or roofing, or leaks around door and window casings. Exposure to heat from the sun causes the moisture to migrate to the surface of the wood and collect under the paint film to form blisters. You can alleviate this condition in two ways:

1. By reducing the humidity inside the building to safe limits.
2. By preventing the moisture from reaching the siding.

Humidity inside the structure can best be controlled by operating humidifiers at lower settings, proper ventilation, and repairing leaks in plumbing, sidewalls, and roofing. In new construction you can prevent moisture from reaching siding by installing vapor barriers between insulation and plaster. In existing structures apply a moisture-resistant paint to interior ceilings and sidewalls. After rectifying the cause, scrape and sandpaper all blistered areas before painting.

Chalking

Chalking is caused by action of sunlight on paint film. A layer of oil is present on the surface of new paint film,

which is destroyed by the ultraviolet rays in sunlight. This leaves loosely bound particles of paint on the surface that wash off during rain. Slight chalking is desirable because it makes the surface self-cleaning. Heavy chalking is undesirable as it washes away, leaving the surface unprotected. Heavy chalking usually occurs on wooden surfaces which were not properly primed and did not receive an adequate number of finish coats. The porous wood sucks the oil out of paint, thus promoting heavy chalking. You can avoid this condition by properly applying a primer sealer followed by two finish coats. To remedy this condition, remove the heavy chalk by scrubbing and wirebrushing before applying paint.

Crawling or Creeping

Crawling, frequently referred to as CREEPING, is the tendency of a paint or varnish to form a discontinuous film by crawling up into drops or globules shortly after application. This results from surface tension caused either by the surface or by the paint. Warm paint applied over a cold, greasy, or waxed surface may cause crawling. Other causes are applying paint or varnish over previous coats that are not hard and dry, the presence of moist finger marks on a surface prior to varnishing, the mixing together of various brands of varnish, the use of varnish that has become thick and viscous, and applying paint in cold or foggy weather.

Dirt Collection

Dirt collection on a painted surface indicates that either there is excessive dirt in the air, or that the paint film is not chalking properly or both. In industrial areas where the dirt content of the air is high, it is advisable to delay painting until there is a minimum of winds. You can alleviate the dirt collection by scrubbing with soap and water, then rinsing with fresh water. Use a chalking paint on your repainting job. Adding oil to paint will

cut down the ratio of pigment to vehicle, and will aggravate dirt collection. Therefore, if necessary to thin, use a paint thinner.

Fading of a Color

Most paints change color on prolonged exposure to the weather. This may be a true fading of color, but generally it is the result of a chemical change in the pigment on exposure to the weather, or excessive chalking of the paint. Some paints chalk evenly and fade evenly. Other paints chalk unevenly, resulting in a blotchy color effect. This is particularly true in dark grays. Spotty fading of color, or so-called blotching, occurs where a porous surface has not received sufficient coats of paint or has not been suitably primed. Use the standard Navy exterior wood primer to uniformly seal all exterior surfaces. The so-called fading of color of paint on interior plaster because of "hot spots" in the plaster (lime burning) is usually caused by the variable suction or porosity of the plaster.

Copper and bronze fly screens cause unsightly discoloration on white and light tinted paints. The discoloration is a result of corrosion products from the screen wire and may be avoided by varnishing or painting the screens before corrosion takes place.

Flaking, Cracking, and Scaling

When you paint wooden surfaces which are saturated with water (over 25 percent moisture), in a short time you will have a paint failure known as flaking, cracking, or scaling. Adhesion of the paint is poor and shrinkage of the wood upon drying out will cause the paint film to crack and flake off. Before attempting to paint exterior wooden surfaces, always wait until the weather is dry—at least a week after a rainy period.

This type of paint failure is caused also by painting over pitch pockets and knots in pine wood. Resin in the

pitch bleeds into the paint, making the film too hard and brittle. When this occurs, the paint film lacks the flexibility necessary to withstand the expansion and contraction of the wood caused by temperature changes. To prevent this condition, be sure to seal pitch pockets with ready-mixed aluminum paint. Prime all exterior wooden surfaces with exterior wood white primer. The only remedy for old painted surfaces is to scrape off all loose paint and repaint according to directions for new exterior wooden surfaces.

Gas Discoloration

In areas where industrial fumes or sewer gases are prevalent you will find gas discoloration in white or light-tinted paint films. Here, hydrogen sulfide reacts with the lead in paint to form a gray or black lead sulfide which is similar to graphite. This condition is usually found on newly applied soft paint films (3 to 6 months) which are permeable to the hydrogen sulfide gas. Affected paint films may lighten up during periods of gas-free air. You can remove the deposits of lead sulfide by sponging with hydrogen peroxide or a weak solution of acetic or muriatic acid. Remove the chemicals from the surface by flushing with fresh water. If the gas discoloration persists, repeat the sponging and flushing process, and then apply a coat of fumeproof paint. By all means make certain that these acid solutions do not come in contact with your skin.

Loss of Gloss

On outdoor paints the first sign of weathering is loss of gloss, followed by chalking. Gloss is produced by the type and quantity of the vehicle used in the paint. Sunlight, air, and moisture cause these binding materials to deteriorate, resulting in loss of gloss. Other conditions causing loss of gloss are inadequate preparation of the surface, insufficient drying time between coats, painting in cold weather, incorrect use of alkaline cleaners on paint,

or exposure of the freshly painted surface to frost, fog, or moisture.

Mildew

Mildew affects paint films in southern localities where the humidity and warm temperatures are suitable for its growth. Mildew produces a black or green discoloration. You must scrub mildewed surfaces thoroughly with soap and water. Rinse with fresh water and allow a few days for drying. Add a prepared mildewcide (½ ounce to 1 gallon) to your paint, mix thoroughly, and apply.

Peeling

Peeling is the result of poor adhesion, which is insufficient bonding of paint to the underlying surface. In order to obtain good adhesion be sure the surfaces are properly treated and are dry, clean, and wax free. Sand all glossy surfaces.

Running and Sagging

Running and sagging may occur when a paint is improperly formulated or is applied too freely. If an old paint surface is too glossy, or the surface is improperly prepared, the new paint may sag.

Suction Spotting

Three to six months after application you may notice a curious light spotting on light gray and other light tints. This paint failure is called suction spotting. It is caused by porous areas in wooden surfaces which absorb the oil from the paint. This leaves an insufficient binder in the paint film to resist weathering. Generally, this condition results when only two coats of paint are applied to wooden surfaces. As a rule, you will find that if a priming coat and two coats of paint are applied, suction spotting will be prevented.

Tackiness and Slow Drying

Tackiness and slow drying may be caused by insufficient drier in the paint or varnish; the use of poor quality vehicle; too liberal an application of paint; the application of paint or varnish during damp, wet, or foggy weather; or the application of paint over wax, oil, or grease. Certain kinds of paints and varnishes lose drying power if stored too long in the original containers. Therefore if there is a possibility that the paint is old stock, its drying properties should be tested before use. If the drying power has been lost, a little paint drier should be added and the paint should be retested until it is determined that it dries properly.

Washing

Paint failure, called washing, occurs when the outer layer of paint film washes off. Finding accumulations of dry pigment at the foot of exterior sidewalls indicates this failure. This washing away of paint is caused by the formation of soluble inorganic and organic water compounds. The formation of these compounds is due to the improper drying of paint during cold and damp weather. Always bear in mind that prolonged moderate temperatures and light are necessary for the complete drying of paint films. Therefore, when possible, painting should be done during that time of the year when you have maximum sunlight and fairly constant temperature.

Wrinkling

When a paint is applied too liberally, particularly during cold, damp weather, the top of the film surface dries first leaving the paint beneath this skin soft. The result is that the finished surface has a wrinkled appearance. To avoid this, each coat of paint should be well brushed out in a skillful manner, especially during cold weather. Particular care must be exercised in spray

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painting to avoid excess film thickness and resulting wrinkling. When a marked drop in temperature (20° F.) is predicted for the evening of the day that paint is to be applied, painting should be discontinued early in the afternoon. In any event, paint should be applied only between the hours of 10 a. m. and 3 p. m., during cold weather (45° to 55° F.).

SUMMARY

To sum it all up, there are five reasons why some paint coats will have a short life:

1. Improper preparation of the surface before painting.
2. Improper application of paint materials.
3. Selection of the wrong type of paint for a given surface.
4. Neglecting to determine if a surface is suitable for the application of paint.
5. Use of a poor quality of paint.

The last item (number 5) is not a problem as you will be using standard Navy paints in most cases. You can learn to avoid these various paint failures and do your painting assignments well by:

1. Observing painting operations.
2. Actual experience and practice.
3. Studying chapters concerning paints and their application in this Navy Training Course.

QUIZ

1. Before lumber becomes finished work, it must be prepared for the application of paint, varnish, or some kind of wood preservative. Of what does this preparation consist?
2. What three types of planes are used most frequently by a builder?
3. For what is the jack plane used?
4. In what direction is the cut made when using the jack plane?
5. For what is the smooth plane used?
6. For what will you use the block plane?
7. When do you use the scraper?
8. Why should you never use gasoline or benzine to clean wooden surfaces?
9. Why is sea sand never used in making sandpaper?
10. Sandpapers are divided into two types. Name these two types.
11. What is the usual procedure in sandpapering?
12. Define the term "the cut of the file."
13. How are single- and double-cut files classified?
14. What is the most satisfactory method of obtaining a clean surface for painting masonry?
15. What is the first requirement of a good plaster surface?
16. What is the wash that is used on new plaster to prevent the lime from reacting with the oil in the paint?
17. What is the best protective paint for iron or steel?
18. Name some of the different types of paint failures.
19. How can you learn to do your painting assignment well?

CHAPTER 4

COMPOSITION AND STORAGE OF PAINT

COMPOSITION OF PAINT

Paint consists of four essential ingredients—pigment, vehicle, drier, and thinner. To make any paint, the pigment is ground into the vehicle; next, the drier is added; and then the thinner which makes the paint the proper consistency for use with brush or spray gun. Now let's examine each of these ingredients.

PIGMENT

There are four general types of pigments: hiding pigments, usually white, which give covering power to the paint, or help to make it opaque; colored pigments, which are used for their coloring properties; strengthening pigments, which improve the durability of the paint; and extenders.

Paint extenders, or inert pigments, are those which are chemically stable and do not affect color or destroy the life

of the vehicle. They are used for various purposes: to provide a less expensive base for certain kinds of colors, to decrease the amount of chemically active pigments in the paint, to limit spreading power and increase the thickness of the paint film, to make a good primer coat base for the finish coat, or to help prevent settling or caking in the container.

COLORED PIGMENTS

There are two kinds of colored pigments—natural pigments, chiefly oxides of iron and other mineral substances which have been used since the earliest times; and chemical pigments, produced in the laboratory, which outdo nature in the variety and brilliance of their colors. Both are used extensively in paint manufacture.

One of the most important considerations in painting and decorating is the skillful use of color. The Navy's guide for the use of color ashore is "Application of Color to Shore Establishment." This publication specifies the twenty-six standard colors to be used. Its recommendations for the use of color for decoration, marking safety hazards, and painting specific buildings, equipment, and areas are to be followed.

VEHICLE

The vehicle in a paint is the liquid portion, acting as a binder and brushing medium for the pigment particles. It wets the surface to be painted, penetrating into the pores and ensuring the adhesion of the film which is formed by the drying of the vehicle.

At the present time, most of the Navy paints do not contain raw oils of any kind. These paints are made with processed oils in combination with synthetic resins. These quick-drying vehicles dry partially by oxidation and partially by polymerization, a process whereby two or more similar molecules combine chemically to form a

larger molecule of a new substance. Thus they are not at all similar to the older paints which contained raw oils. This is another reason why raw oils should never be added to Navy paint. If the paint is thick and needs to be thinned, add some mineral spirits. Never add diesel oil, varnish, or like materials.

VARNISHES

Varnish is used as a vehicle and also as a separate coating. As a vehicle it is found chiefly in primers and enamels where hardness, gloss, water resistance, and similar properties are desired.

The varnishes used by the Navy may be classified under two types—oil varnishes (such as spar varnish and interior varnish) and spirit varnishes (such as shellac and damar varnish).

Oil varnishes are solutions of synthetic or natural resins, drying oil, volatile solvents, and metallic driers. They dry or harden partly through evaporation and partly through oxidation. Oil varnishes should be allowed plenty of time to dry before another coat is applied. Twenty-four hours is a safe period.

Spirit varnishes are made from gums or resins that are soluble in alcohol, turpentine, acetone, or similar volatile solvents. They contain no drying oils, and dry by evaporation, usually quite rapidly.

DRIERS

Certain metallic compounds when mixed with oil add to the drying properties of paint. These are called driers, and as used in the Navy, consist chiefly of compounds of lead, manganese, and cobalt napthenates.

A paint drier acts as a conveyer of oxygen which it takes from the air and adds to the oil. This speeds the oxidation, or drying, of the paint. Without the use of a drier, absorption of oxygen would be too slow a process.

THINNERS

As you can tell from the name, thinners are used to reduce the consistency of the paint to the proper degree for application by spraying or brushing. They also increase the penetration of the paint into the surface and cut down the gloss. Too much thinner, however, will reduce the proportion of the vehicle. As you remember, the vehicle is the binder; so if it is diluted too far, the durability of the paint will be affected.

The thinner you will be using most often is mineral spirits, a petroleum solvent which evaporates faster than kerosene but slower than gasoline. Turpentine is sometimes used, however, but its high cost makes it impractical and it should be used only for enamels and varnishes. When necessary to thin shellacs, wood alcohol is used.

CAUTION

One word of caution: Practically all of the paints you will be using will be ready-mixed paints. That is, when you draw them from the paint shop, they are ready for use. These paints have been carefully prepared to produce the coatings that will be most satisfactory under the conditions of use. Because ready-mixed paints contain definite proportions of vehicle, pigment, thinner, and drier, you must exercise caution in mixing them with other paints.

There are certain paints which require mixing immediately prior to use. These are zinc dust water tank paint, aluminum paint, and nonskid deck paint (which contains pumice). If these paints were mixed and then stored, the heavier particles would settle to the bottom. The zinc dust, aluminum paste, or pumice should be added in exactly the quantity needed, and the paint should be stirred frequently while being used.

Aluminum paint and zinc dust paint should always be freshly mixed just prior to use. If they are left standing

any length of time, they lose the important property of leafing. Leafing is the ability of an aluminum or gold bronze paint to exhibit a brilliant or silvery appearance. Use these paints the same day that they are prepared. When kept in a sealed container, these paints have a tendency to become gaseous. The gases will blow the top off the can, leaving the paint exposed to the air, and any paint left in the can will be ruined. So mix aluminum paint and zinc dust paint only as needed and use them right away.

TYPES OF PAINT

As you know, there are many different kinds of paint. For example, you cannot use the same type of paint on wood trim as you would on side walls. There are different paints for exteriors and interiors; for wood trim, metal work, plaster ceilings, and side walls. Before you start, make sure you have the right paint for the right job.

Navy standard paints give excellent durability in paint films and should be applied by spray gun or brush in the lightest coat possible which will still cover the surface. A film of about 0.0007 inch is recommended in order to conserve weight, minimize fire hazard, and prevent cracking and peeling.

PAINT PREPARATION

The very first step in paint preparation is, of course, to open the can the right way. Use a flattened spike or similar tool to pry the lid up ONLY ENOUGH TO LOOSEN IT. In this way, you'll save the bucket and lid for use again.

"Mix well before using"—you've read this instruction often. And it applies to paint, too, because no matter how high the quality of a paint, it will give poor service if it isn't thoroughly mixed before applying. As you may know from experience, when paint has settled in a can, the upper portion contains too much oil and too little pig-

ment. Beware of partial mixing which may appear uniform. Use that mixing stick (figure 4–1) with vigor.

Here's the best system for mixing paints. Pour off most of the clear liquid (oil) at the top of the container and mix the remainder thoroughly. Then add a small amount of the clear liquid and stir well. Repeat the process, using a little liquid at a time until all the oil has been added and the paint is uniform. One more step to make sure the paint is thoroughly mixed: Pour the paint back and forth between two cans as shown in figure 4–2. This process is called BOXING and ensures a smooth and even mixture.

Notice how the correct method of mixing will leave a paint can (figure 4–3). When you open a paint can you may find that a SKIN has formed on the surface of the paint. This must be carefully removed and thrown away. All particles of pigment, dirt, and skin should be taken

Figure 4–1.—How to use a mixing stick.

out by straining the paint through a wire screen or cheesecloth. Straining should be done after the paint has been thoroughly stirred and mixed.

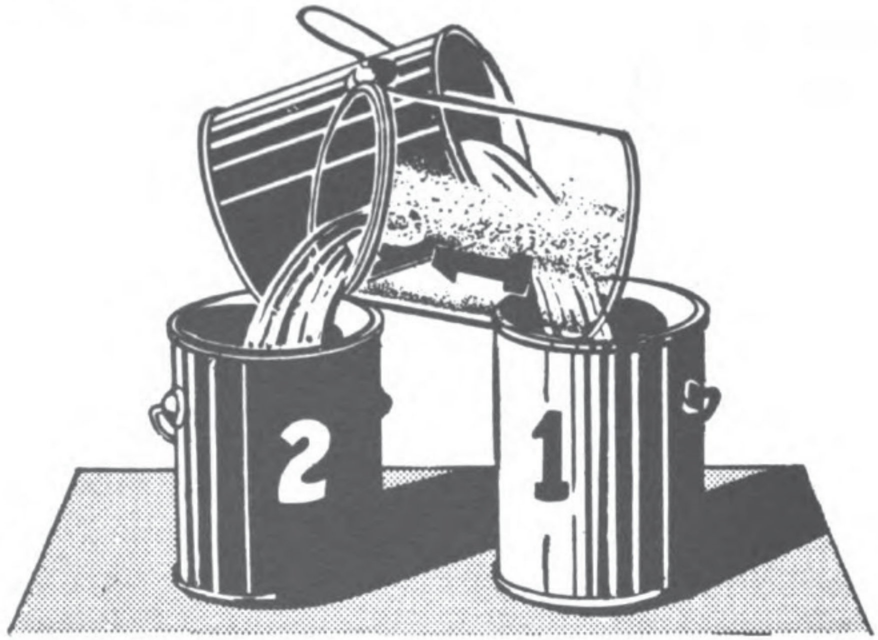


Figure 4–2.—The steps in "boxing."

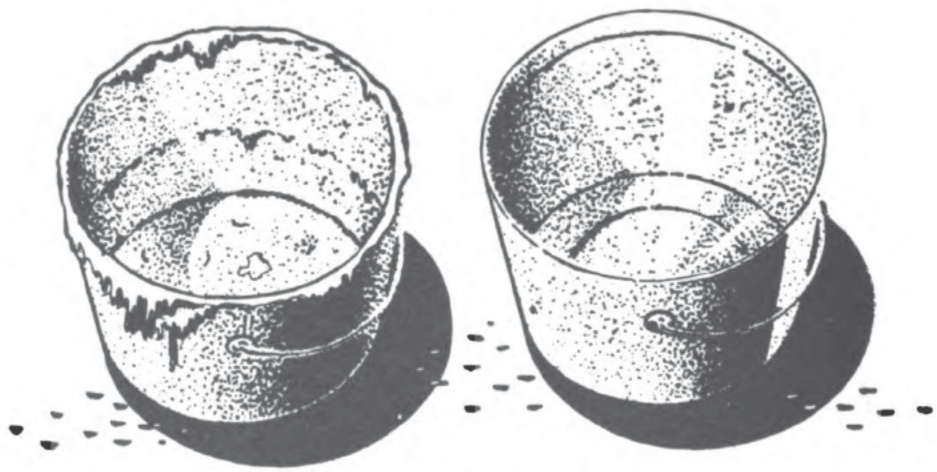


Figure 4–3.—The results of incorrect and correct mixing.

STORAGE OF PAINT AND FLAMMABLE LIQUIDS

Most of the paint for Navy use is delivered in five-gallon drums. These drums are kept at the paint shop and the paint is distributed to the painters in gallon cans

with which it is easier to work. In addition, it makes it easier for you to keep the paint in good condition.

After you've finished your painting job, if there is any paint left in the can, strain it before returning it to the larger drum. You'll be surprised at how much dirt can get into a paint can after the top has been off for only a short time.

When you store paint always place it in a cool, dry spot. Mark cans with the name of the paint, the formula num-

AVERAGE PAINT COVERAGE, BRUSH PAINTING

Type of Surface	Area in Square Feet per Gallon		
	Used as one coat	Used as two coats	Used as three coats
Exterior wood paint:			
Wood siding	470	250	180
Shingle siding	340	190	
Exterior trim paint:			
Wood trim	850	435	300
Exterior oil paint:			
Brick	200	150	
Cement cinder block	180	105	
Stucco	150	125	100
Exterior cement water paint:			
Brick	100	60	
Cement cinder block	100	60	
Stucco	100	60	
Shingle stain:			
Shingle siding	150	90	
Shingle roof	120	80	
Porch and deck paint:			
Wood	380	200	165
Concrete	450	260	180
Flat oil paint, plaster (over primer)	540	290	
Gloss oil paint, plaster (over primer)	540	270	
Emulsion paint or casein water paint (plaster)	540	310	
Enamel, interior trim (over primer)	400	225	
Varnish, floor	540	270	180
Shellac, floor	540	300	220

ber, and date of manufacture—and keep tightly sealed. Cans should be turned bottom up at least once every three months. When new stocks of paint are obtained, they should be stored so that the oldest paint is used first.

PAINT REQUIREMENTS

A good painter knows just how much paint he will need. Over many years of practice he has learned to judge the porosity of surfaces and can tell the approximate area a gallon of paint will cover. You, too, will learn through experience, but you can begin to learn by using the chart on page 67 as a guide.

QUIZ

1. If paint is too thick, what is usually added to make it thinner?
2. What are the two types of varnishes used by the Navy?
3. Why are thinners used in paint?
4. What primer is used most frequently by the Navy?
5. How does the drier in paint work?
6. Describe, briefly, the best process for mixing paint.
7. What publication would tell you what color to paint a first-aid equipment locker?
8. How many standard colors are used in the Navy Shore Establishment?
9. Explain the process of boxing as applied to paint mixing.
10. To thin shellac you use:
    a. mineral spirits
    b. wood alcohol
    c. kerosene
    d. turpentine
11. What paints require mixing immediately before use?

CHAPTER 5

EXTERIOR AND INTERIOR PAINTING

WHY USE PAINT?

In the Navy, paint is used primarily for the preservation of surfaces. It seals the pores of wood and steel, arrests decay, and helps prevent the formation of rust. However, paint also serves a variety of other purposes. It is valuable as an aid to cleanliness and sanitation, both because of its antiseptic properties and because it provides a smooth, washable surface. Paint is also used to reflect, absorb, or to redistribute light. For example, light-colored paint is used in the interior of a room to distribute natural and artificial light to the best advantage. These same properties of reflection and absorption, incidentally, make camouflage painting possible. For these and other reasons, the Navy uses a great deal of paint.

BRUSH PAINTING

Smooth and even painting depends as much on good brush work as it does on good paint. There is a brush

for almost every purpose; so be sure you use the right brush and keep it in the best condition. Figure 5–1 illustrates most of the types of brushes used in the Navy.

You can identify the brushes in the illustration by the corresponding numbers. Numbers 1, 2, and 3 are standard 2″, 3″, and 4″ black china bristle brushes generally used for painting walls. Numbers 4 and 5 are the standard 1″ and 2½″ fitch brushes with skunk and black china bristles used with shellac, lacquers, and varnishes. Numbers 6 and 7 are standard 1″ and 4″ pure triple thick badger bristle brushes used for flowing varnish. Number 8 is made of standard 1½″ white Russian bristles which are double thick; it is generally used for flowing varnish and enameling; 9 and 10 are standard 1″ and 3″ camel's hair bristles, used only for color coats on undercoatings for varnish on automobiles. Number 11 is a standard 3″ bear bristle brush used with shellac, lacquer, varnish, and enamel. Numbers 12 and 13 are standard 2″ Siberian ox-hair bristles, also used for shellac, lacquer, varnish, and enamel. Numbers 14, 15, and 16 are the standard 2/0, 6/0, and 8/0 black china bristle, oval, painter's general purpose paint and varnish brushes. Numbers 17 and 18 are the standard ½″ and 1″ molding, scrubbing, or rubbing brushes used for pumice and oil, or for cleaning work; 19, 20, and 21 are the standard 1″, 1½″, and 2″ black china bristle brushes used for varnish flowing or for general household purposes. Number 22 is the standard 2″ round painter's duster; 23 is the standard 4″ flat painter's brush; 24, 25, 26, and 27 are the standard ½″, ¾″, 1″, and 1½″ oval sash tools, with black china bristles, for painting window sash.

You will be using them all, but the two most commonly used will be the fitch and flat brushes listed above. The flat brush, particularly, is a good jack-of-all-trades and is especially practical for painting rough work. The fitch brushes because of their size are good for cutting edges, wood trim around glass, and hard-to-get-at places.

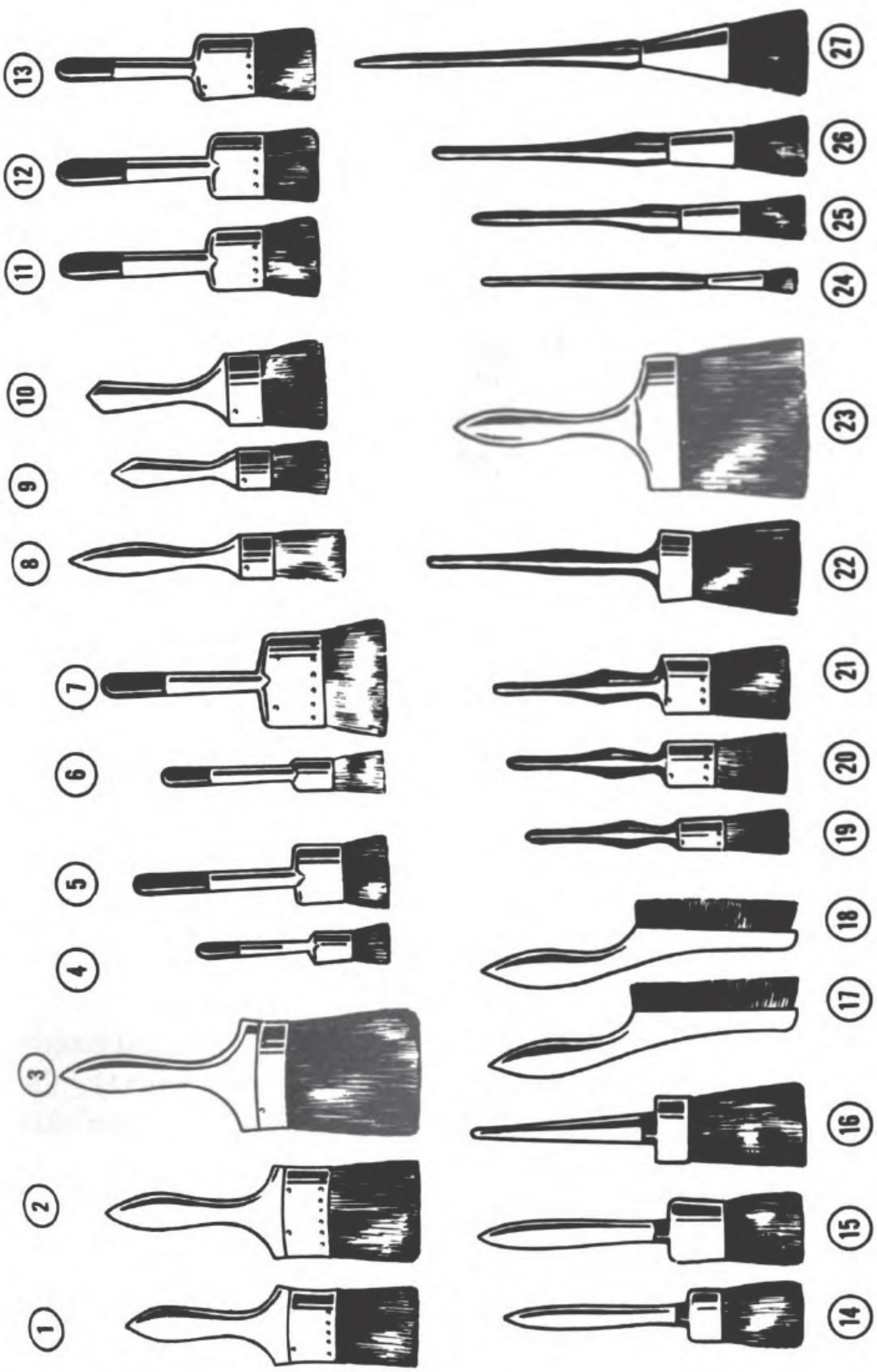


Figure 5–1.—Types of brushes.

Horsehair has been substituted for hog-hair bristles, which are becoming difficult to obtain, particularly Russian hog-hair, which is very scarce. You may find also that many of the newer brushes are being made of nylon. Actually, paint brushes with tapered nylon bristles last much longer than those made with animal bristles. Your brushes are safer from pests like moths and rodents, too, since these pests can't eat nylon.

CARE OF BRUSHES

Brushes are only as good as the care that you give them. The best brush can be ruined very quickly if not properly treated. If you follow the suggestions given here, you'll find that your brushes will last longer and give better service.

In the old days, when the bristles of paint brushes were set in wood, painters used to dampen the wood to make it swell so that it would hold the bristles more tightly. Now, however, in nearly all modern paint brushes the bristles are set in rubber or in some composition material. This means, of course, that wetting the end of the handle holding the bristles is useless. In fact, this practice will probably do more harm than good because it will tend to make the metal ferrule rust faster.

To prevent the bristles in a round brush from spreading it is advisable to bind the heel end (at the metal band) with cotton line. As the bristles become shorter, the binding can be removed. You don't need to follow this process with flat brushes—they are not so likely to spread.

CARE AFTER USE

Your first step after using a paint brush is to give it a thorough cleaning in a paint solvent such as turpentine substitute, or mineral spirits. If you let a brush stand in water, the bristles will lose their elasticity. After cleaning, brushes in daily use can be hung in a slotted,

galvanized tank to prevent distortion of the bristles. Usually, these tanks are designed so that each slot or runway holds a particular type of brush in the proper solution at the right height (about an inch off the bottom) to check spreading of the bristles. Separate runways contain oil for varnish brushes; shellac solution for shellac brushes, and linseed oil for paint brushes. Brushes may also be suspended in makeshift holders by placing a wire through the handles, but the tank arrangement is more satisfactory.

Here is a tip that will be helpful if you run across a paint brush that has become hard. Soak it for about 24 hours in raw linseed oil, then in hot turpentine. Generally, you will find that this will loosen up the bristles, making them workable.

Varnish brushes are cleaned with turpentine substitute, or mineral spirits; lettering brushes are washed in turpentine substitute. If you are not going to use the brushes again for some time, it is advisable to dip them in oil and smooth them from heel to point.

Shellac brushes should never be kept in water. Clean them with alcohol and store them in a small amount of mixed shellac and alcohol.

Old or worn brushes can be kept to spread rust-preventive compounds and similar materials. Very old brushes are handy for applying cleaning solutions and paint removers, even though they won't last long when you start using them that way.

Before you start to use a brush for painting, drain the oil from it. Then wipe the bristles clean and wash them in a solvent or some other oil remover. You then will find the brush very easy to work with and the bristles pliable.

Remember, after brushes have been used, they should never be left in an open can of paint or exposed to air. Good brushes are hard to get. Clean them immediately after using, and store properly.

HOW TO USE A BRUSH

There is an art to using a paint brush properly. It is an art you will have to master if you are going to become a good painter. The following general hints will help you. Read them over once to see how many mistakes you have been making; then, take each point separately and concentrate on it until you have mastered it.

First of all, don't grab the brush as if you were afraid it might get away from you. Hold it firmly (figure 5–2), but lightly. Hold it so that you use a free and easy wrist motion plus the action of your arm.

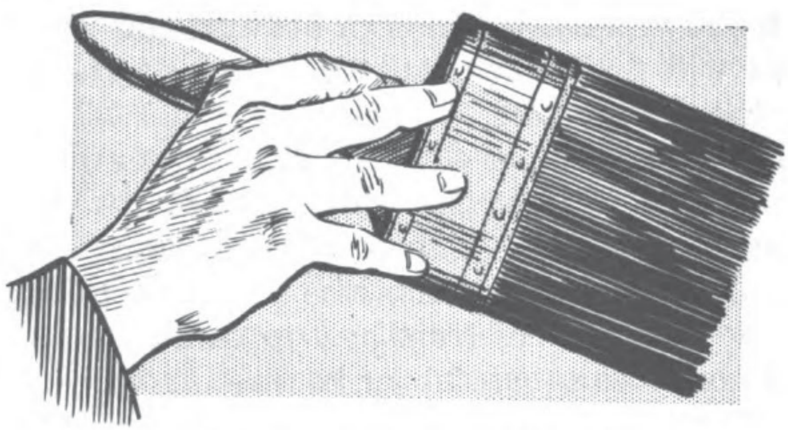


Figure 5–2.—Correct way to hold a brush.

When you pick up the brush, don't put your fingers on the bristles below the ferrule or metal band. If your fingers are on the bristles they are sure to become smeared with paint. Should you happen to have any small open cuts on your hands, this may lead to blood poisoning. Besides, by exerting too much pressure on the center of the brush, the brush will wear into a fishtail shape.

When using a flat brush, don't try to paint with the narrow edge. Using the narrow edge will wear the corners down and spoil the shape and efficiency of the brush. When using an oval brush, don't let it turn in your hands. An oval brush that has been revolved too much will wear to a pointed shape and become useless. Don't poke oversize brushes into corners and around moldings—that will

ruin a good brush by bending the bristles. Use a smaller brush that will fit into such odd spots.

Before you start to apply the paint to the surface, work the paint well into the brush. This is done by holding the mixing paddle tightly over the rim of the bucket, dipping the brush into the paint, then wiping the brush clean across the edge of the paddle. Do this several times so you will be sure the brush is filled with paint.

When applying paint, dip only the ends of the brush into the can. Tap it lightly against the side of the can; then apply it to the surface to be painted. Every brush has a certain capacity and if you overcharge it, paint will drop all around the work. This is particularly important when working overhead. You will look like an Indian with a full coat of war paint if your brush is too full.

Hold the brush at right angles to the surface being painted with the ends of the brush just touching the surface. Lift the brush clear of the surface when starting the return stroke. If the brush is held obliquely and is not lifted, the painted surface will be uneven, showing laps and spots and giving a "daubed" appearance. Also a brush that is held at too great an angle will soon wear away at the ends.

Similarly, a brush on which too much pressure is exerted in the center will wear into a fishtail shape; you can always tell whether or not an old brush has been used properly. If it has received good usage it will wear down evenly all around.

Here's how to apply paint by brush. For complete coverage follow the Navy style and first "lay on," then "lay off." Figure 5–3 illustrates this procedure. "Laying on" means applying the paint first in long horizontal strokes, "laying off" means crossing your first strokes by working up and down.

By using this method and crossing your strokes, the paint is distributed evenly over the surface, the surface is completely covered, and a minimum amount of paint is used. A good rule is to "lay on" the paint the shortest

distance across the area and "lay off" the longest distance. When painting vertical surfaces "lay on" in horizontal strokes, "lay off" vertically.

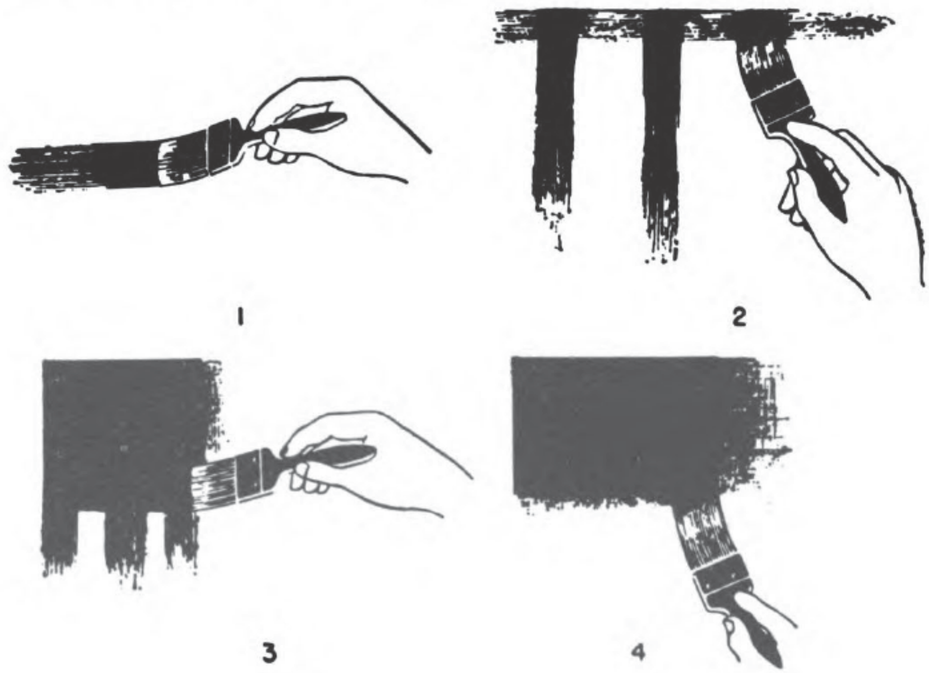


Figure 5–3.—Correct application of paint, "laying on" first, then "laying off."

If you plan to paint both interior sidewalls and ceiling of a room, start with the ceiling. Paint only a narrow stretch at a time across the shortest dimension of the ceiling, so you can get back on the next strip before the edge of the first is dry. Joining on a dry edge will leave a lap mark that will show when dry. When painting sidewalls start at the top and carry each stretch down to the baseboard. Keep strips narrow so you are always working with a wet edge. Don't go back over a painted area to eliminate brush marks. Finish entire ceiling or wall without stopping.

If two men are working together, one man may work at the top, "laying on" and "laying off" downward; the bottom stretch man can start at the bottom, "laying on" and "laying off" upward. This will give a wet edge that will blend into a perfect finish without showing where each man worked.

A coat of paint that is too heavy will show brush marks and have an uneven finish. Better results can be gained if you apply two thin coats of thin (or medium) body paint rather than one heavy coat of heavy paint. You get more spread with two thin coats; one coat doesn't have as much penetrating quality as two thin coats. Moreover, a heavy coat marks up and scratches easily, whereas thin coats dry to a harder surface.

Wait until the first coat is completely dry before applying a second coat. Paint dries because it is exposed to air. It won't dry properly if covered too soon.

Stir the paint continually while you're working with it. If it is left undisturbed, the pigments will settle to the bottom and you will be painting mostly with oil.

Now do you begin to see that there is a lot to knowing how to use a paint brush? Old hands at painting have the know-how, but they learned it by experience just as you will. After a while you will find all these rules come naturally to you.

Ventilation is important, too, because proper ventilation is necessary to carry off the solvents and furnish oxygen so that the paint will dry properly.

To avoid brush marks when finishing up a square, use strokes directed toward the last square finished, gradually lifting the brush near the end of the stroke while the brush is still in motion. Every time the brush touches the painted surfaces at the start of a stroke, it leaves a mark. For this reason, never finish a square by brushing toward the unpainted area, but always end up by brushing toward the area already painted.

WORKING CONDITIONS

One important rule about temperature is that painting should not be done when the temperature is below 45° F. Painting is always more satisfactory when it is done in

warm weather. There is a good reason for this. Below 45° F. the thinner evaporates slowly and the oxidation of the vehicle is retarded. As a result, the paint will not dry properly and will blister in warm weather. You may, of course, paint interior surfaces that are dry, if the temperature can be kept above 45° F. for paints, and 65° F. for enamels and varnishes. Do not paint when surfaces are wet with dew or frost, while rain, snow, or sleet is falling, or when weather forecasts indicate precipitation within several hours. Defer painting until surfaces are dry.

You wili have to watch the humidity too. If there is too much moisture in the air it is likely to condense on the walls and make painting difficult. To reduce the humidity you do one of two things—increase the temperature, or add some fresh air.

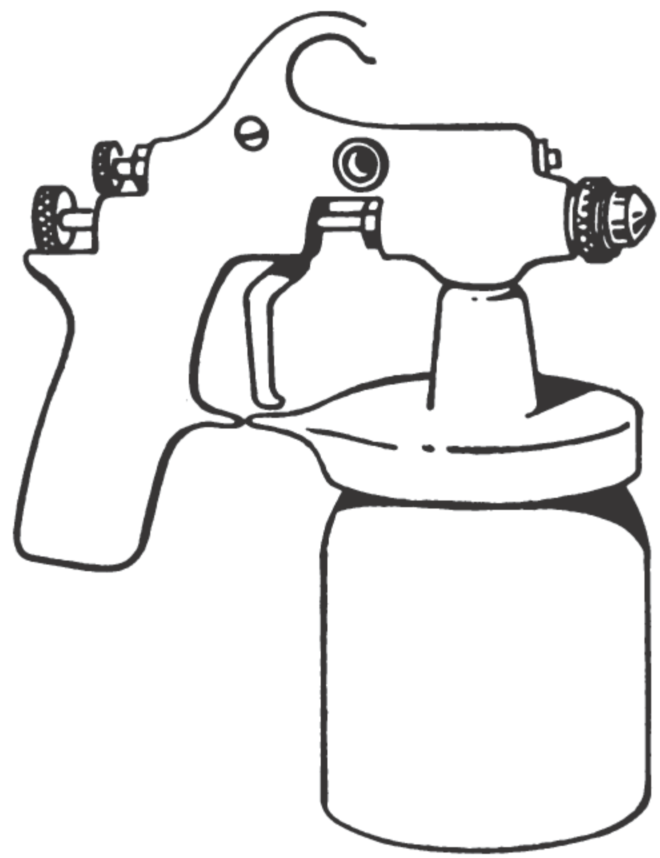


Figure 5-4.—An attached container-type spray gun.

In general, a spray gun is a precision tool that mixes air under pressure with paint, breaks it up into spray, and shoots it out in a jet. There are several types, but all are either an attached container type (figure 5–4) or the separate container type (figure 5–5). They are further classified into bleeder or non-bleeder, external- or internal-mix air caps, and the suction feed or the pressure feed cap.

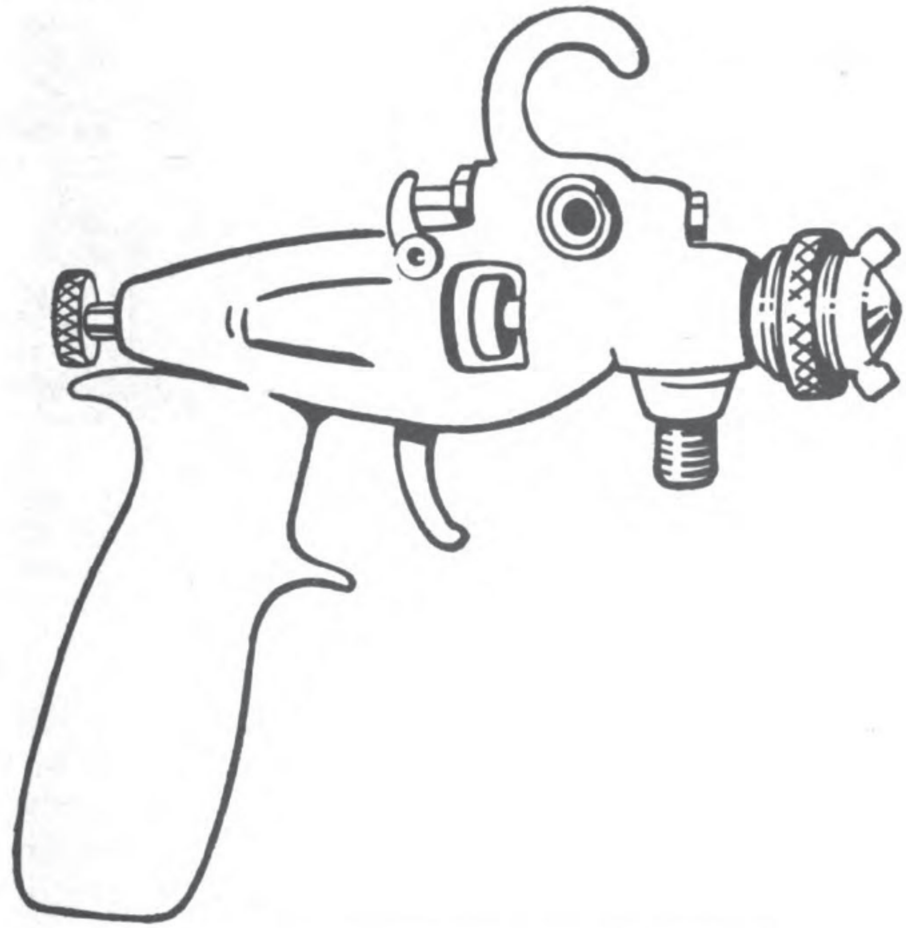


Figure 5–5.—A separate container-type spray gun.

OPERATION OF THE SPRAY GUN

Look at figure 5–6. See what happens when you pull the trigger on your spray gun. It opens an air valve and admits compressed air through the air inlet, and from

there the air passes through the gun body into the spray head. If you are using the more common type of spray head—the external mix type—the air doesn't come into contact with the spray material inside the gun, but is forced out through small holes drilled in the air cap. Here it is directed against the fluid which has entered the gun through the fluid inlet and which is also forced out of the gun's nozzle under great pressure. As a result the paint is blown into a fine spray. You can control this spray and make it into various patterns by setting the dial which regulates the spreader adjustment valve.

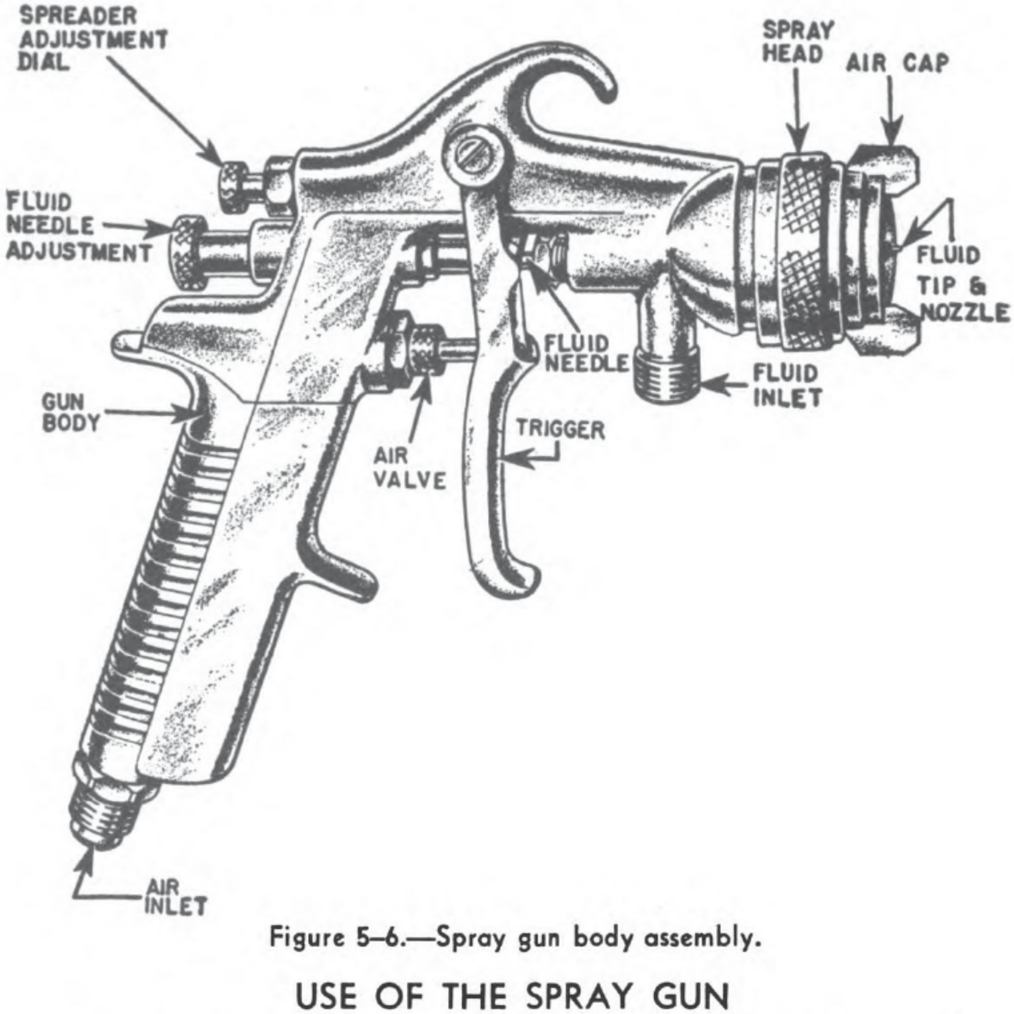


Figure 5–6.—Spray gun body assembly.

USE OF THE SPRAY GUN

The handling of a spray gun is learned best by practice. This training course can, however, give you a valuable background for using the spray gun.

Two elementary rules are: (1) the spray gun must be thoroughly clean, and (2) you must have plenty of air at the gun. For most purposes you will use 45 to 50 pounds of pressure for lacquer, and 60 to 70 pounds for heavier material, such as enamel.

As a spray gun operator you will develop your own technique as you gain experience in spray painting, but there are certain signposts which should be followed if you are to do an efficient job.

First of all, watch the distance from gun to sprayed surface. Most operators have found that this should be from 6 to 8 inches for best results. Carefully observe figure 5–7.

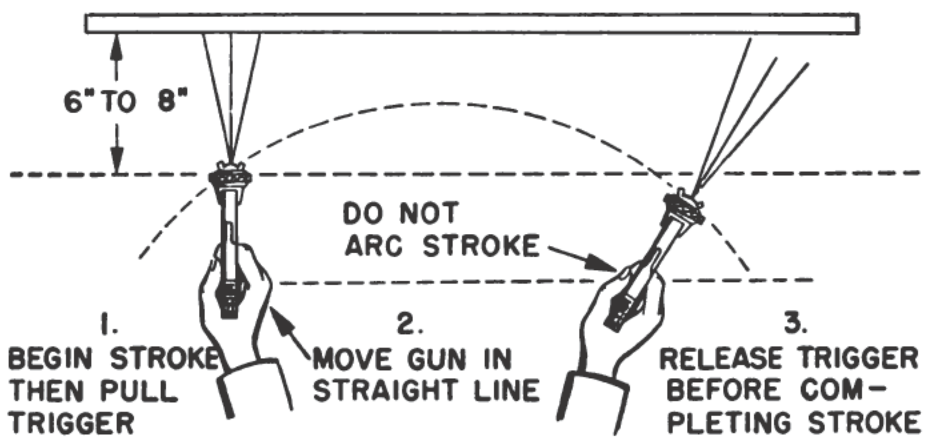


Figure 5–7.—The right and wrong spray motions.

Next, always hold the gun at right angles to the surface (except when spraying corners). Move the gun with a straight, even motion, not in an arc. If you use a circular motion, you will end up with too much paint in the center and too little at the ends.

Finally, begin the motion before you pull the trigger, and release the trigger before you end the stroke. Then you'll be sure to have an even application with no runs.

When you're spraying an area into which small parts and pieces protrude, spray those parts lightly first, then go over the whole surface. For example if you are spraying a room, spray one coat around the door casings and

windows; then do the entire room. This method eliminates "bridging" and touching up later.

SPRAYING CORNERS

There is a trick to spraying corners as figure 5–8 shows. First, spray up to within one or two inches of the corner; then, turn the gun on its side; starting at the top, spray downward along the edge so that you will catch both sides of the corner at once.

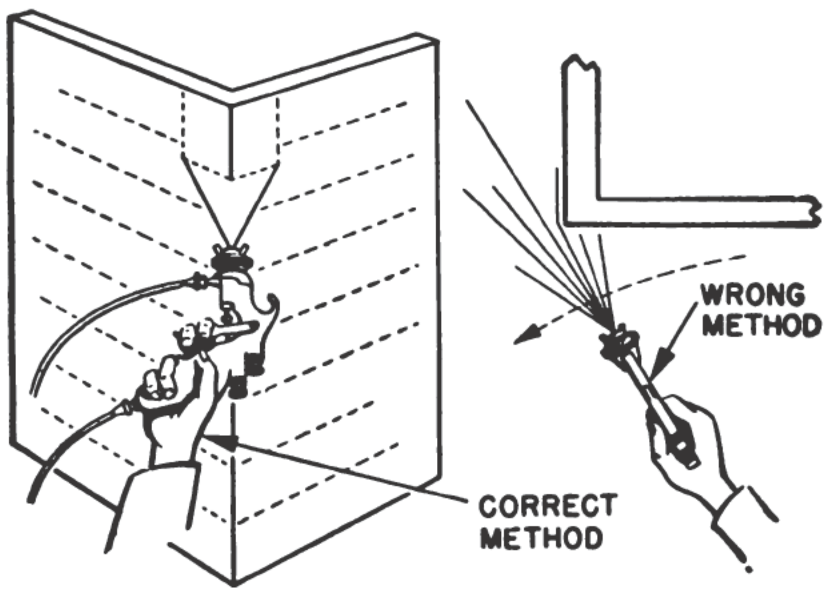


Figure 5–8.—Right and wrong way to spray corners.

CARE OF THE SPRAY GUN

You cannot expect a gun to give you good service unless it's kept clean. This rule applies to spray guns too. The job of cleaning a spray gun is easy and it's one that will repay you in more efficient operation. But, if you occasionally skip the cleaning job, you will find the gun developing all sorts of trouble. Clean your spray gun thoroughly before you put it away—EVERY TIME.

The steps in cleaning a pressure feed gun are shown in figure 5–9. First, back up the fluid needle adjusting screw and release the pressure from the pressure tank by means of the release valve. Hold a cloth over the air cap and pull the trigger—this forces the spray material back into

the tank. Now remove the fluid hose from the gun and run a solvent through it. There is a special hose cleaner made for this purpose. Dry out the tip and clean the tank. Soak the air cup in a solvent. If the air holes are clogged, use a tooth pick to clean them. Put all clean parts back in place, and the gun is ready for use again.

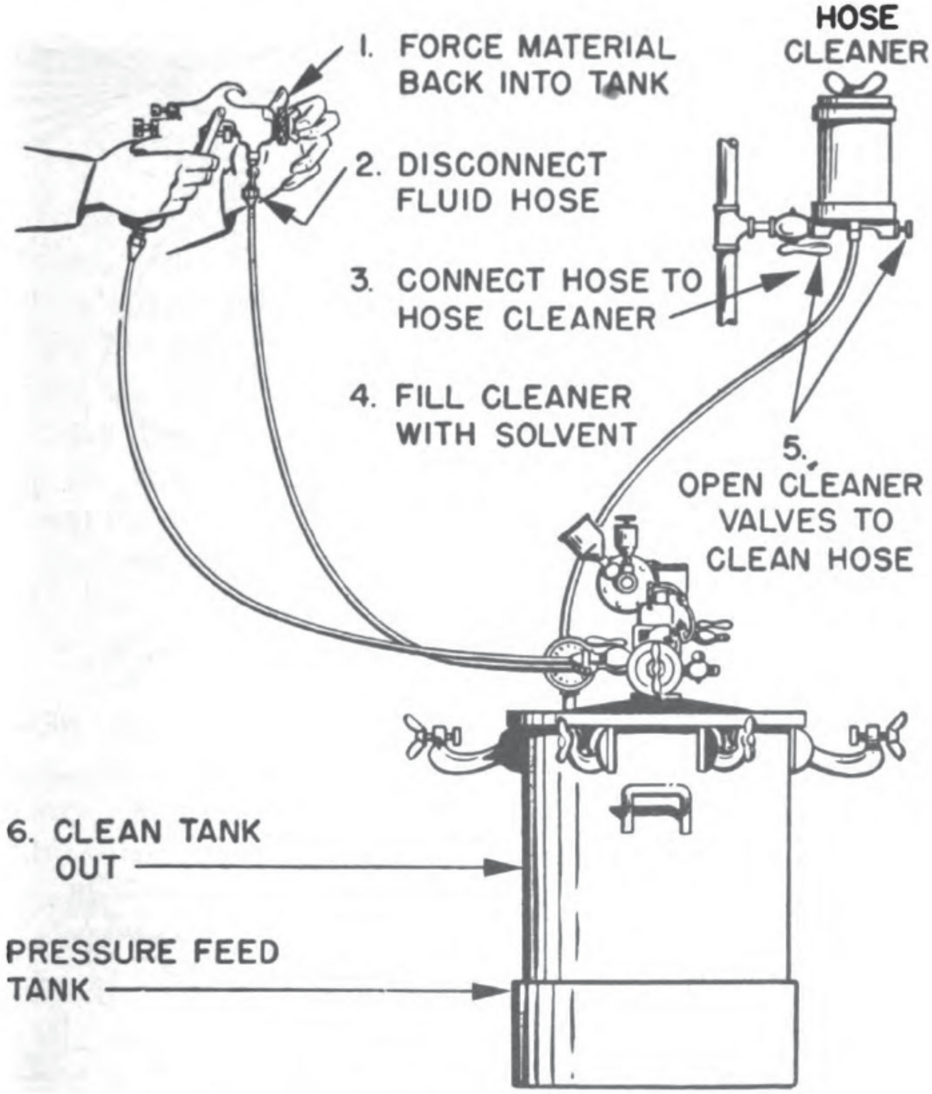


Figure 5–9.—Steps in cleaning a pressure feed gun.

To clean a container-type gun (figure 5–10), first remove the container. Then hold a cloth over the air cap and pull the trigger. Empty the container and pour in a small quantity of solvent. Attach the container to the

gun and spray it in the usual way. This process cleans out all passageways. Clean the air cap by soaking it in a solvent, and then replace it.

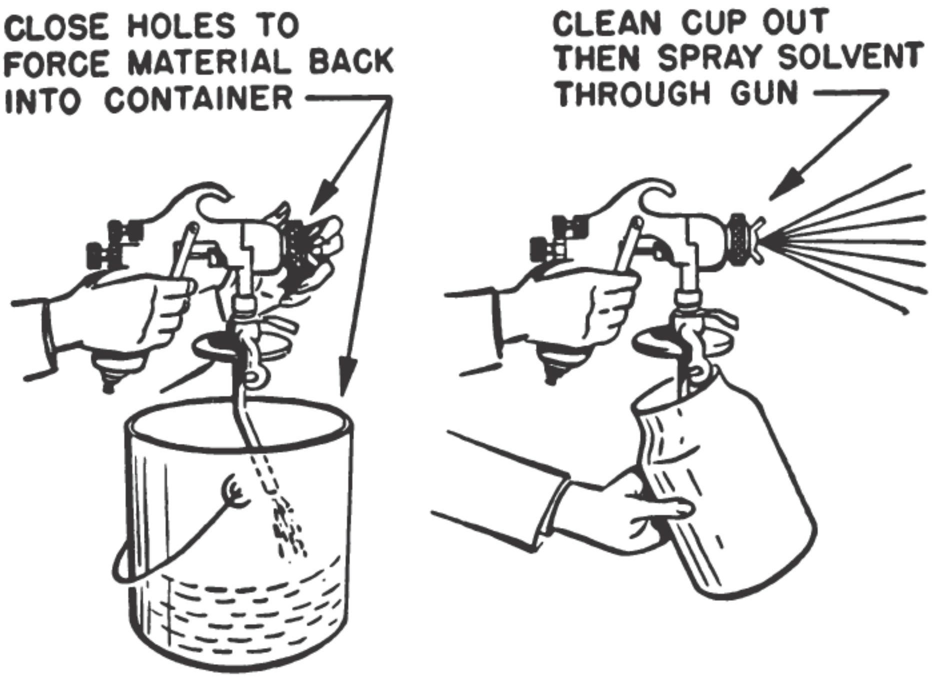


Figure 5–10.—Steps in cleaning a container-type gun.

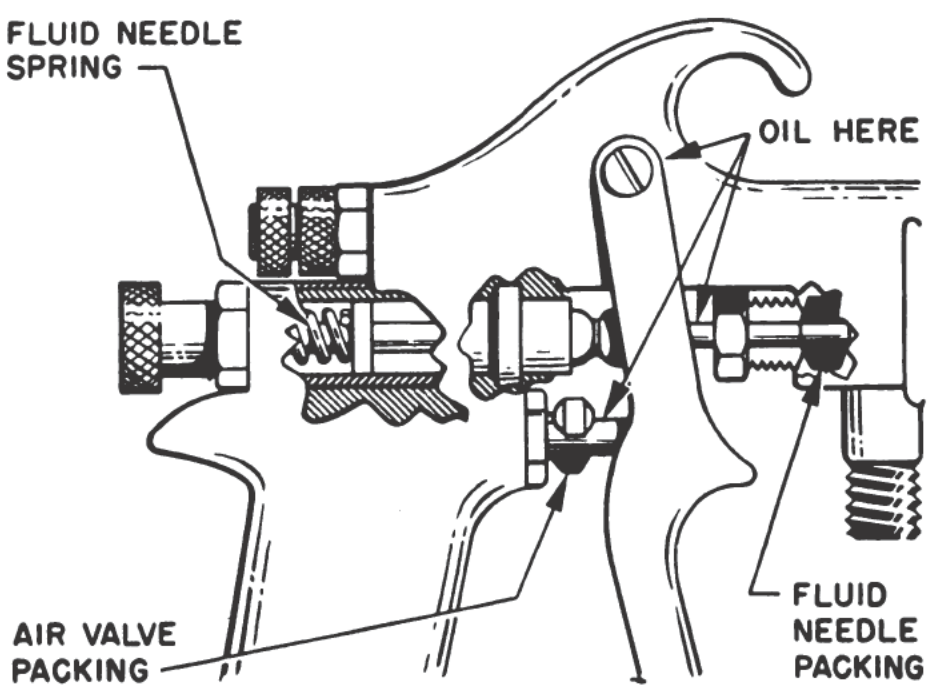


Figure 5–11.—Lubrication points of a spray gun.

LUBRICATION OF THE SPRAY GUN

Your spray gun also needs a little lubrication. Again, this is a small job but well worthwhile. The fluid needle packing should be removed occasionally and softened with oil. The fluid needle spring should be coated with grease or petrolatum. Figure 5–11 shows where these parts are, and also the oil holes in which you should occasionally put a few drops of light oil.

HOW TO REMOVE THE SPRAY HEAD

For cleaning or repairing, or when changing the color of paint, you may have to change the spray head. In modern spray guns, this is a simple operation. First, remove the gun from the air and fluid hose lines. Then, holding the gun in the left hand, pull the trigger all the way back and loosen the locking bolt with the wrench provided for this purpose. Push the trigger forward as far as possible, then pull the spray head forward. To replace the head, push the trigger forward and insert the spray head. Then hold the trigger back and tighten the locking bolt.

SPRAY PAINT FAILURES

The common paint failures in spray painting are "orange peels," runs and sags, pinholes, blushing, peeling, and bleeding.

"Orange peel" is a general term used to describe a painted surface which has dried with a pebbled texture resembling an orange peel. This may be caused by the use of improper thinner, insufficient atomization, holding the gun too far from or too close to the surface, improper mixture of material, drafts in the finishing room, or low humidity.

Runs are usually the result of using material that is too thin; sags result from too much thinner. They can also be caused by allowing too big a lap in spraying strokes and by poor adjustment of the spray gun or pressure tank.

Dirty or partially clogged passages for air or fluid will also cause uneven distribution.

Pinholes may be caused by the presence of water or excessive thinner in the paint, or by too heavy an application of quick-drying paint. In either case, small bubbles will form and break in drying, leaving small holes.

Blushing resembles a powdering of the paint caused by the cellulose material separating from the solvent and returning to its original powder form. Water is usually the cause—either moisture on the sprayed surface or excessive moisture in the air.

Almost invariably, peeling is caused by carelessness in not cleaning the surface properly. Before any spraying is attempted, the surface must be absolutely clean. Sometimes cheap spray materials also will give poor adhesion. You won't have this trouble if you use the standard Navy paints.

When any of the above spray paint defects occur, you will have to remove the defective coating because the moisture is trapped within the material and will remain there unless the coating is removed.

WHAT NOT TO USE IN YOUR SPRAY GUN

As a general rule, Navy paints, enamels, lacquers, synthetics, varnishes, and shellacs are suitable for spray work with ordinary equipment. Material containing small gritty particles such as plastic and mastic paints should never be used in standard equipment. They will damage the ordinary machine; so apply them only with equipment made especially for the purpose.

ROLLER COATING

Roller coating is another method of applying paint which has proved practical. There are three types of hand roller coaters: dip, can, and pressure. All three types consist essentially of a cylinder covered with lamb's wool, flat knit wool or cotton, or short pile carpet material. The

cylinder rolls about an axle through its center which is attached at both ends to a two-pronged handle of the necessary length.

Dip Type

The dip type requires a flat pan or container into which the roller can be dipped to receive a charge of paint which is simply rolled onto the surface to be painted. This process is repeated somewhat like recharging a brush in brush painting.

Can Type

The can type is essentially the same as the dip type except that the cylinder is a perforated can. Paint is poured into the can and is sucked out through the perforations by the sponge action of the lamb's wool as it is rolled over a surface.

Pressure Type

The pressure type is essentially a can type with provisions made for forcing paint from a separate container through a hose into the can. The pressure type container holds from 2 to 5 gallons and is provided with a hand pump by which air pressure is maintained above the liquid. This type is well suited to large surfaces, since it eliminates the frequent dipping and refilling required by the dip and can types.

USE AND CARE OF ROLLERS

Rollers eliminate much of the work involved in rigging, staging, and scaffolding. Inaccessible areas can be satisfactorily painted by attaching long handles to the rollers. This method of applying paint has been found very effective for interior sidewalls and ceilings.

The use of rollers is limited, however, to plain surfaces or surfaces on which the lamb's wool roller will penetrate. It is best not to use rollers for surfaces such as pipes, beams, rails, shingles, drop or lap siding, and the like.

Roller coaters should be cleaned immediately after use by washing thoroughly in the cleaner or thinner recommended for the paint which was used. After cleaning with thinner, the cylinder cover should be washed thoroughly with soap and water, rinsed, then dried on the roller to prevent shrinkage. Combing lamb's wool while damp will prevent matting.

STRIPING

You will probably do a great deal of striping, and striping can be a relatively easy job if you use masking tape, an adhesive material which can be attached to almost any surface without moistening and which can be removed easily without tearing the tape or injuring the surface. You can use either brush or spray gun with masking tape. There are two basic methods to be followed, the choice depending on whether the surface to be striped has been finished.

STRIPING METHOD NO. 1

If the surface is already painted and you don't want to do a complete repainting job, you can still add stripes without injuring the finish. Here is how: First decide on the position and width of the stripe; then apply masking tape to both sides of the stripe. It is advisable to add a further protective covering on both sides of the stripe wide enough to prevent daubs or overspray from striking the rest of the surface. This protection may be provided by placing newspapers or wrapping paper in the proper position before painting. The striping color is then sprayed or brushed on; when the paint has set, the masking tape is removed.

STRIPING METHOD NO. 2

If the surface is unfinished, the process of striping is a little different. First decide on the position and width of the stripe; then spray or brush the color on, allowing it to overlap the edge of the stripe a little on both sides.

Allow the striping color to dry thoroughly, and then cover the exact area of the stripe with masking tape. The tape should be attached firmly, but not stretched too much.

Rub or roll it down to smooth out the wrinkles and make it a tight protective covering. Some painters recommend for your next step a light "fog" covering of the finishing material right over the tape. This will help to prevent the final coat of paint from sticking to the edges of the tape and cementing the tape to the surface. Now you're ready to spray or brush on the finishing coat. Do this right over the masking tape. Then, when the surface coat has set, the tape may be removed to reveal a clean-cut stripe.

There may be slight ridges along the edges of the stripe after you have pulled off the masking tape. If a ridge is too noticeable, you can scrape it off after it has dried thoroughly, then rub it smooth with a rubbing compound.

REMOVING MASKING TAPE

There is a little trick to removing masking tape so it won't mar the surface. The right way is to pull the tape off somewhat diagonally and back upon itself. The wrong way is to pull the tape directly away from the surface at a right angle. Work slowly, with your hands moving close to and parallel to the surface.

PAINT STRIPERS

If a paint striper (see figure 5–12) is handy, you will not have to use a brush or spray gun. It can be held in the hand like a fountain pen and pulled across the surface

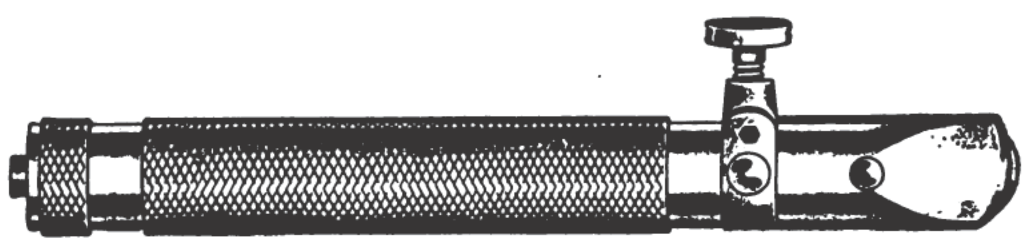


Figure 5–12.—A paint striper.

to be striped. Single, double, or triple stripes can be produced, side-by-side, by adjustment of the guides. The paint striper paints straight or curved evenly-spaced lines with a minimum of preparation and effort.

GLASS AND GLAZING

You will probably have to do a great deal of installing glass and glazing windows. Glazing is the process of setting glass in the sash with triangular pieces of zinc called glazier's points, which are forced or driven into the wood or sash over the glass and bearing against the glass, and then covered with putty. The glass may also be held by means of strips of molds made of wood for wooden sash and metal for metal sash. Rabbets of 1/4 inch or more in depth are provided in the sash to support one side of the glass.

The puttied face of a wooden sash is placed outside. Before the glass is set, place putty on the rabbet of the sash. The glass is then pressed into the putty to an even bearing. This operation is known as "bedding." The glass is held in places with triangular pieces of zinc known as glazier's points. The remainder of the rabbet is then filled with putty and smoothed off with a putty knife. This is called "face puttying." "Back-puttying" consists of forcing putty into any spaces which may be left between the edges of the rabbet and the glass. Glazier's molds are usually used instead of face putty for setting glass indoors.

On steel windows the putty surface is usually on the outside but may be on the inside. In the more expensive grades of metal sash, metal molds or strips are used instead of putty. The glass is preferably back-bedded and back-puttied.

Besides common window glass there are other kinds used in building construction, such as plate glass, wire glass, ornamental and colored glass, skylight glass, and so on.

The best quality of glass is specified as AA, the second as A, and the third as B. It is graded as double-thick or single-thick, and each thickness is further divided into three qualities; first, second, and third. This grading is based upon the color and brilliancy, and the presence or absence of flaws in the material. Single-thick glass is approximately $\frac{1}{16}$ inch in thickness; double-thick, approximately $\frac{1}{8}$ inch.

Stock sizes of window glass vary in size from 6 inches to 16 inches in width. Above that they vary by even inches up to 60 inches in width and 70 inches in length for double thickness, and up to 30 inches by 50 inches for single thickness.

SAFETY FIRST

One rule a good painter never forgets is "safety first." When you are working long periods on certain painting projects, you are likely to get careless. This is no excuse to let up in your duty to exercise common sense and good judgment in your work at all times. By observing the rules given in the following paragraphs you will be playing it safe at all times.

Some paint and varnish removers contain flammable ingredients. You should never use them around an open flame. Also, they are poisonous, and you will find that the best policy is to wear rubber gloves. If rubber gloves are not available, inspect your hands to see if you have any open cuts or sores. If you have, lay off painting. Watch out especially for your face, eyes, and mouth. Don't use paint removers in confined areas. If paint and varnish removers touch the skin and start to burn, apply cold water immediately to wash it off. Consult the doctor in case you get a burn. Don't let it go.

Smoking is prohibited in the paint shop, mixing room, and immediate areas. "No smoking" means exactly what it says.

Always wear a respirator when spraying or when you are in the vicinity of spray work. Respirators are especially designed to give you maximum protection. Some-

times blowers can be set up to take foul air out and blow fresh air in. This is true when spray painting is done in tight places.

Immerse sweepings and deposits in metal containers of water, or burn them outside the building. Do not burn residues in stoves, furnaces, or other heating devices; deposits of lacquer exposed even to moderate temperatures release flammable and explosive gases.

Avoid exposing paint and varnish materials to the first rays of the sun and to devices producing excessive heat, smoke, spark, and flame. Do not use lanterns, oil lamps, or torches in the paint shop.

Keep all compartments used for the storage of paint free of rubbish and unnecessary combustible materials. Absolute cleanness is essential.

Hang soiled clothes in locations that have plenty of fresh air. Change and launder soiled clothing frequently.

Work cleanly. At the end of the day, clean all work benches with a putty knife, thinner, and rags. Drain all drip pans under pumps or faucets into closed metal containers and wipe pans clean with dry rags.

Dispose of all oily rags after painting—each day.

Do not paint any electrical equipment without the approval and supervision of the Construction Electrician's Mate.

The practice of good personal hygiene by painters is necessary to prevent skin irritation and limit the transfer of small but often times significantly toxic amounts of paint to the mouth where it will be swallowed. Do not eat in places where food may be exposed to lead paint, dust, or fumes. Wash hands and face carefully before eating.

Avoid use of thinners to remove paint from the hands. To overcome any tendency to dryness and chapping of the skin, use an ointment containing a mixture of lanolin and olive oil, castor oil, or cottonseed oil, rubbed well into the skin. Wait at least ½ hour before washing hands with soap and water.

Accidents in painting usually are caused by faulty lines, cables, work platforms, ladders, and scaffolds. Be careful, and don't paint until you are sure it is safe.

RECOMMENDED READING

You can obtain useful reference books from your Information and Education Officer. You will also want to review *Basic Hand Tool Skills,* NavPers 10085, containing general information concerning the handling of paint brushes. *Damage Controlman 3 & 2,* NavPers 10571–C is a valuable reference for ship painting. You may also obtain further technical advice from official technical publications of the Bureau of Yards and Docks.

QUIZ

1. What is the primary use of paint in the Navy?
2. Name some of the purposes of paint.
3. What are the two most commonly used types of paint brushes in the Navy?
4. What causes a brush to wear into a fishtail shape?
5. How can you prevent the bristles in a round brush from spreading?
6. Describe the proper method of applying paint.
7. How do you prevent brush marks when finishing up a square?
8. What are the two types of spray guns?
9. Give the two elementary rules for spray painting.
10. Describe the trick for spraying corners.
11. What are some common spray paint failures?
12. Name the three types of roller coaters.
13. What is window glazing?
14. How is glass graded?
15. In glazing windows, what is "bedding"?
16. What is "face puttying"?
17. Describe the two striping methods.
18. Name the ways accident occur in painting.
19. What equipment can you use for paint striping which does not involve either brush or spray gun?

CHAPTER 6

WOODWORKING TOOLS AND BUILDING HARDWARE

Just before the Revolutionary War, nails were uncommon. Pieces of wood were fastened together by different kinds of joints, dowels, and wood pins. The colonists began to make metal nails by hand, and this became a household task. When nail-making machines were introduced, the home industry of making nails was discontinued. These machines produced rectangular or cut nails and were used almost entirely until 1875. Then a machine capable

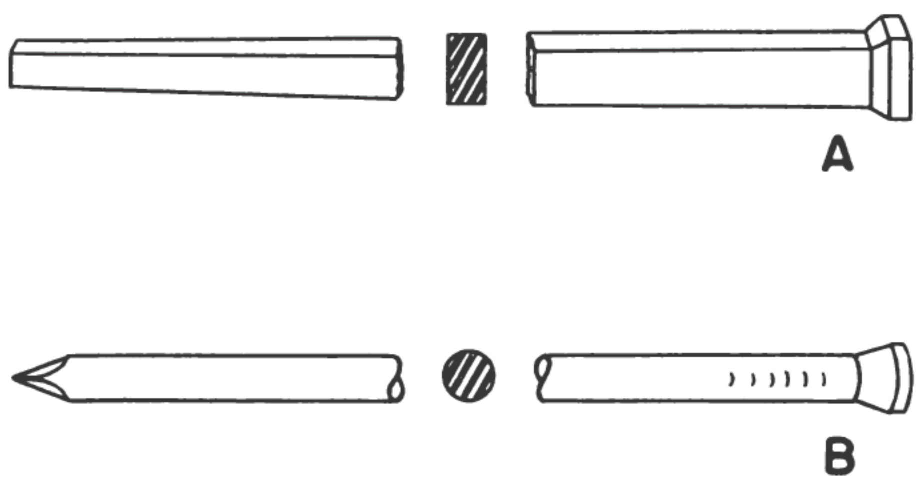
of making wire nails was invented. Cut nails have greater holding power, but wire nails are more frequently used because they can be manufactured at a much lower cost.

CLASSIFICATION OF NAILS

We now have a great variety of nails to meet the needs of all kinds of construction. In reference to shape they are commonly classified into two groups, cut nails and wire nails.

Cut Nails

Cut nails are all rectangular in shape and of different lengths, according to their use. They are wedge shaped,



Courtesy of The Bruce Publishing Co.

Figure 6–1.—(a) Cut nail.
(b) Wire nail.

with two parallel sides. The other two sides taper slightly toward the end. Their ends are square, and have no point.

Wire Nails

Wire nails are round, with a diamond-like point, and the shape of their heads varies with their use. They are manufactured in many sizes, ranging from the smallest brad to the longest spike.

COMMON WIRE NAILS

SIZE	LENGTH	GAUGE	APPROX. NO. TO LB.	SIZE	LENGTH	GAUGE	APPROX. NO. TO LB.
2D	1 IN.	NO. 15	876	10D	3 IN.	NO. 9	69
3D	1 1/4	14	568	12D	3 1/4	9	63
4D	1 1/2	12 1/2	316	16D	3 1/2	8	49
5D	1 3/4	12 1/2	271	20D	4	6	31
6D	2	11 1/2	181	30D	4 1/2	5	24
7D	2 1/4	11 1/2	161	40D	5	4	18
8D	2 1/2	10 1/4	106	50D	5 1/2	3	14
9D	2 3/4	10 1/4	96	60D	6	2	11

FLOORING BRADS

SIZE	LENGTH	GAUGE	APPROX. NO. TO LB.
6D	2 IN.	NO 11	157
7D	2 1/4	11	139
8D	2 1/2	10	99
9D	2 3/4	10	90
10D	3	9	69
12D	3 1/4	8	54
16D	3 1/2	7	43
20D	4	6	31

CASING NAILS

SIZE	LENGTH	GAUGE	APPROX. NO. TO LB.
2D	1 IN.	NO. 15 1/2	1010
3D	1 1/4	14 1/2	635
4D	1 1/2	14	473
5D	1 3/4	14	406
6D	2	12 1/2	236
7D	2 1/4	12 1/2	210
8D	2 1/2	11 1/2	145
9D	2 3/4	11 1/2	132
10D	3	10 1/2	94
12D	3 1/4	10 1/2	87
16D	3 1/2	10	71
20D	4	9	52
30D	4 1/2	9	46

FINISHING NAILS

SIZE	LENGTH	GAUGE	APPROX. NO. TO LB.
2D	1 IN.	NO 16 1/2	1351
3D	1 1/4	15 1/2	807
4D	1 1/2	15	584
5D	1 3/4	15	500
6D	2	13	309
7D	2 1/4	13	238
8D	2 1/2	12 1/2	189
9D	2 3/4	12 1/2	172
10D	3	11 1/2	121
12D	3 1/4	11 1/2	113
16D	3 1/2	11	90
20D	4	10	62

SMOOTH & BARBED BOX NAILS

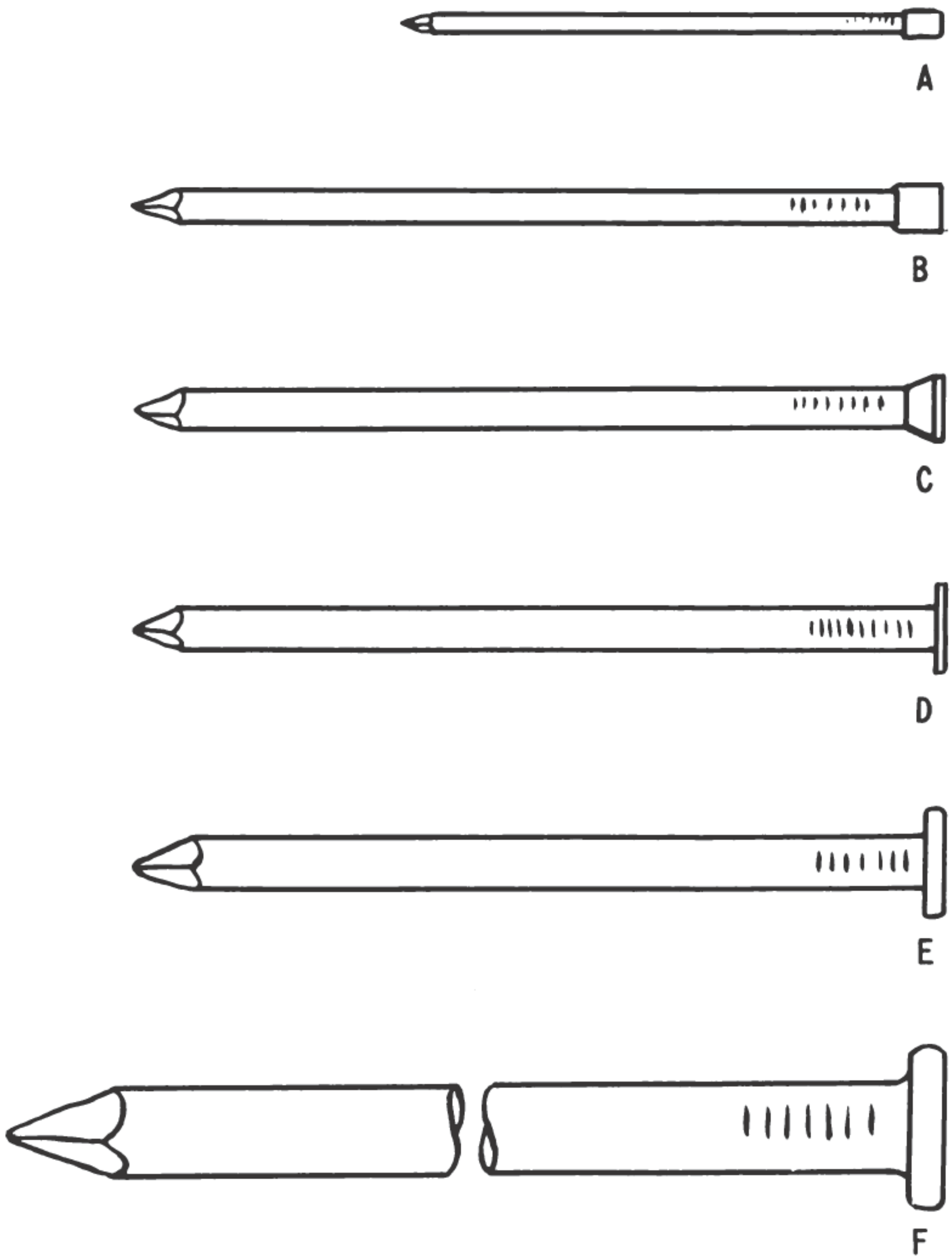
SIZE	LENGTH	GAUGE	APPROX. NO. TO LB.
2D	1 IN.	NO. 15 1/2	1010
3D	1 1/4	14 1/2	635
4D	1 1/2	14	473
5D	1 3/4	14	406
6D	2	12 1/2	236
7D	2 1/4	12 1/2	210
8D	2 1/2	11 1/2	145
9D	2 3/4	11 1/2	132
10D	3	10 1/2	94
12D	3 1/4	10 1/2	88
16D	3 1/2	10	71
20D	4	9	52
30D	4 1/2	9	46
40D	5	8	35

Courtesy of The Bruce Publishing Co.

Figure 6-2.—Nail and brad characteristics.

SIZE OF NAILS

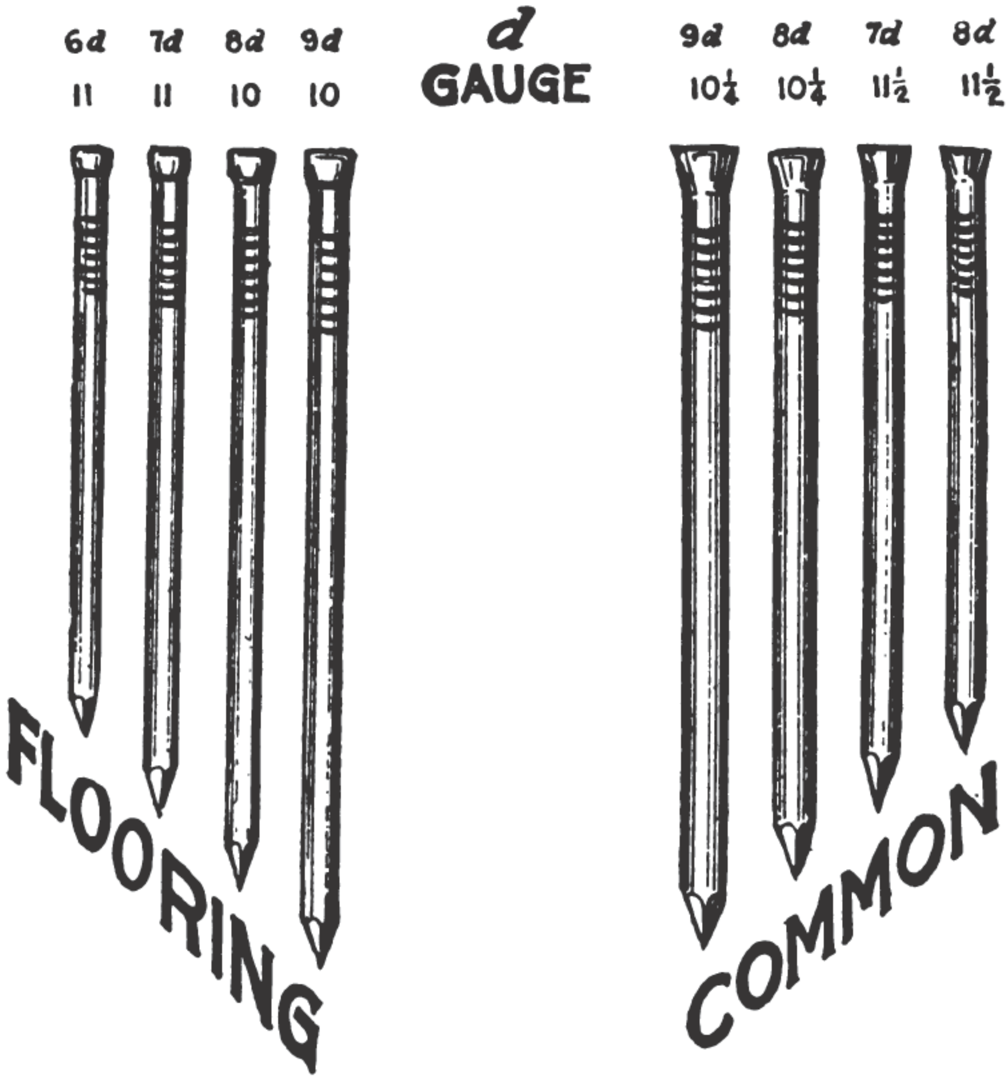
In reference to size, nails are classified into three major groups: nails, spikes, and brads. The sizes of nails are



Courtesy of The Bruce Publishing Co.

Figure 6–3.—Types of nails—(a) Brad, (b) Finishing, (c) Casing, (d) Box, (e) Common, (f) Spike.

expressed by the term "penny" which is abbreviated by the use of the small letter "d." Nails and spikes range in size from the smallest 2d to the largest 100d. The penny size indicates the length but not the diameter of nails and spikes. However, brad sizes are specified differently. The length of a brad is indicated in inches as well as the



Courtesy of Theo. Audel & Co.

Figure 6–4.—Flooring and common brads.

number of the wire from which the brad is made. The chart in figure 6–2 indicates the actual sizes of the most common brads, nails, and spikes.

USE OF NAILS

Nails are also classified according to the type of construction in which they are used (see figure 6–3). These groups are brads, finishing nails, casing nails, box nails, common nails, and spikes.

Brads

Brads are very small slender nails with small deep heads, and are used only on light work such as the material for moldings. The sizes of brads or finishing nails vary from 8d down to 2d, according to the thickness and size of moldings. The common variety of nails is made in sizes from 1 inch (2d) to 6 inches (60d) in length, while flooring brads range from 2 to 4 inches in length. Figure 6–4 indicates a few sizes of flooring and common brads. Notice the difference in the shape of heads and variations in gage numbers.

Finishing Nails

These fasteners range in size from 2d to 40d. Because of the small barrel-shaped heads of finishing nails, you'll be able to drive them below the surface of the wood with a nail set, and then the hole can be filled with putty. The holding power of these nails is not very great, but this is not important as they are primarily used in finish work.

Casing Nails

These nails are made with a tapered head. The diameter of the head is only slightly larger than the diameter of the nail. Casing nails are used to fasten tongue and groove flooring. They range in size from 2d to 40d. Because of their small heads, you can get a tight fit between boards without the heads showing. When you secure ceiling material of $\frac{3}{4}$ inch thickness, use 8d casing nails. For thinner stock, it is better to use 6d casing nails: 6d's are also used to secure weather boarding or siding. Eightpenny casing nails are used in top-flooring for jointed boards, while 6d or 8d are used for matched flooring.

Box Nails

Box nails have large heads like common nails, but are smaller in diameter. Box nails range in size from 3d to 40d. They are lighter in weight than the common nails and are used to fasten thin, lightweight material.

Common Nails

Common nails are the strongest of nails. They range in size from 2d to 60d. You'll use them in ordinary building jobs where holding power is required instead of appearance. Common 8d nails are used to fasten sheathing, roofboarding, subflooring, and cross-bridging.

Spikes

Spikes are similar to common nails except that they are larger in size, ranging from 16d to 60d. Spikes larger

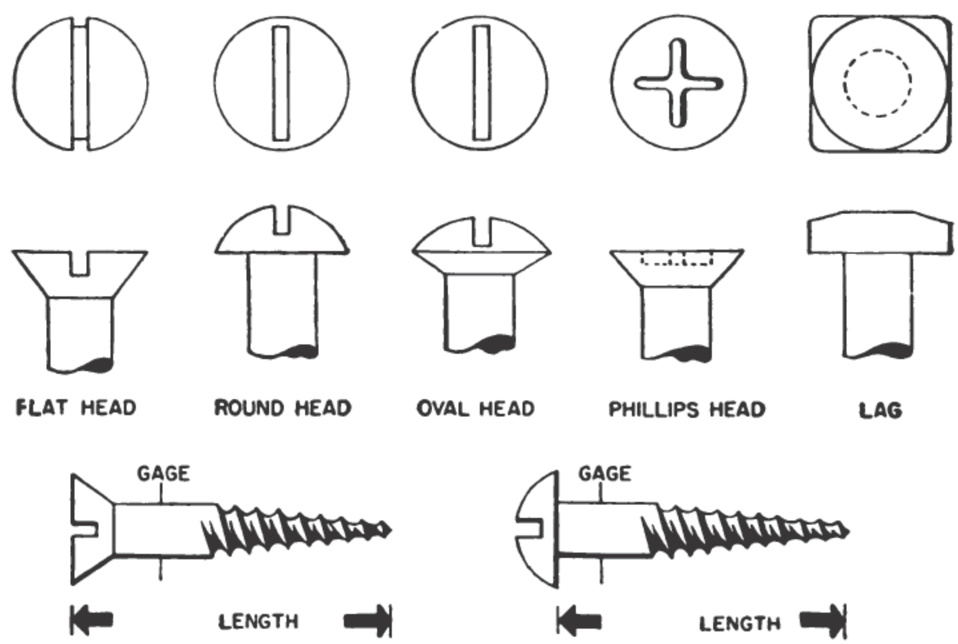


Figure 6–5.—Screws.

than 60d are generally classified in inches, for example: 7, 8, 9, and 10 inch spikes. Spikes are used in heavy construction work to secure logs and heavy timbers. In the building of framing, the size of the spikes to be used

is determined by the size of the timber. Experience will teach you to select the proper sizes of nails for building jobs. However, here is a rule to remember—in cases where you would use an 8d nail on ordinary softwood, use a 7d nail for hardwood of the same thickness.

WOOD SCREWS

In many instances, you'll find the use of wood screws more advantageous than nails. Screws have a greater holding power and present a neater appearance. If you insert them properly, screws will injure material less than nails. Also, you'll be able to remove them with ease. However, more time is required to insert screws than to drive nails and screws are more expensive. Wood screws range in length from ¼ (gage No. 0) to 6 inches (gage No. 30). It is very important that you know how to determine the length of a screw, as the overall length of a 2-inch, flat-head screw is not the same as that of a 2-inch round-head screw. Refer to figure 6–5, to learn about the lengths for the various types of screws. You will notice that each screw has a particular name, such as the flat-head, round-head, and oval-head screw. These are standard screws.

HOW TO PUT IN A WOOD SCREW

To insert a wood screw, bore a hole slightly smaller in diameter than the shank of the screw, and to a depth of about ½ the length of the screw. Place the screw in the hole and drive the screw in by turning it with a screw driver. Never use a hammer to assist in driving a screw.

A lag screw is a heavy service type made with a square or hexagonal head so that you may turn it with a wrench instead of a screw driver. (See figure 6–6.) Lag screws are used where great holding strength is required as in heavy timber construction work.

To insert lag screws, you should bore a hole just a bit larger than the diameter of the unthreaded shank and to

a depth equal to the length of the shank. Then bore a second hole at the bottom of the first hole, a little smaller in size than the diameter of the threaded shank, and to a depth of about ½ the length of the threaded portion. The exact size and depth of this hole depends on the kind of wood you'll be making fast. The harder the wood, the larger the hole must be. You'll find the lag screw hard to turn if the hole is a little small. By smearing the threaded part of the screw with soap or rosin, the resistance can be considerably decreased.

Courtesy of The Bruce Publishing Co.

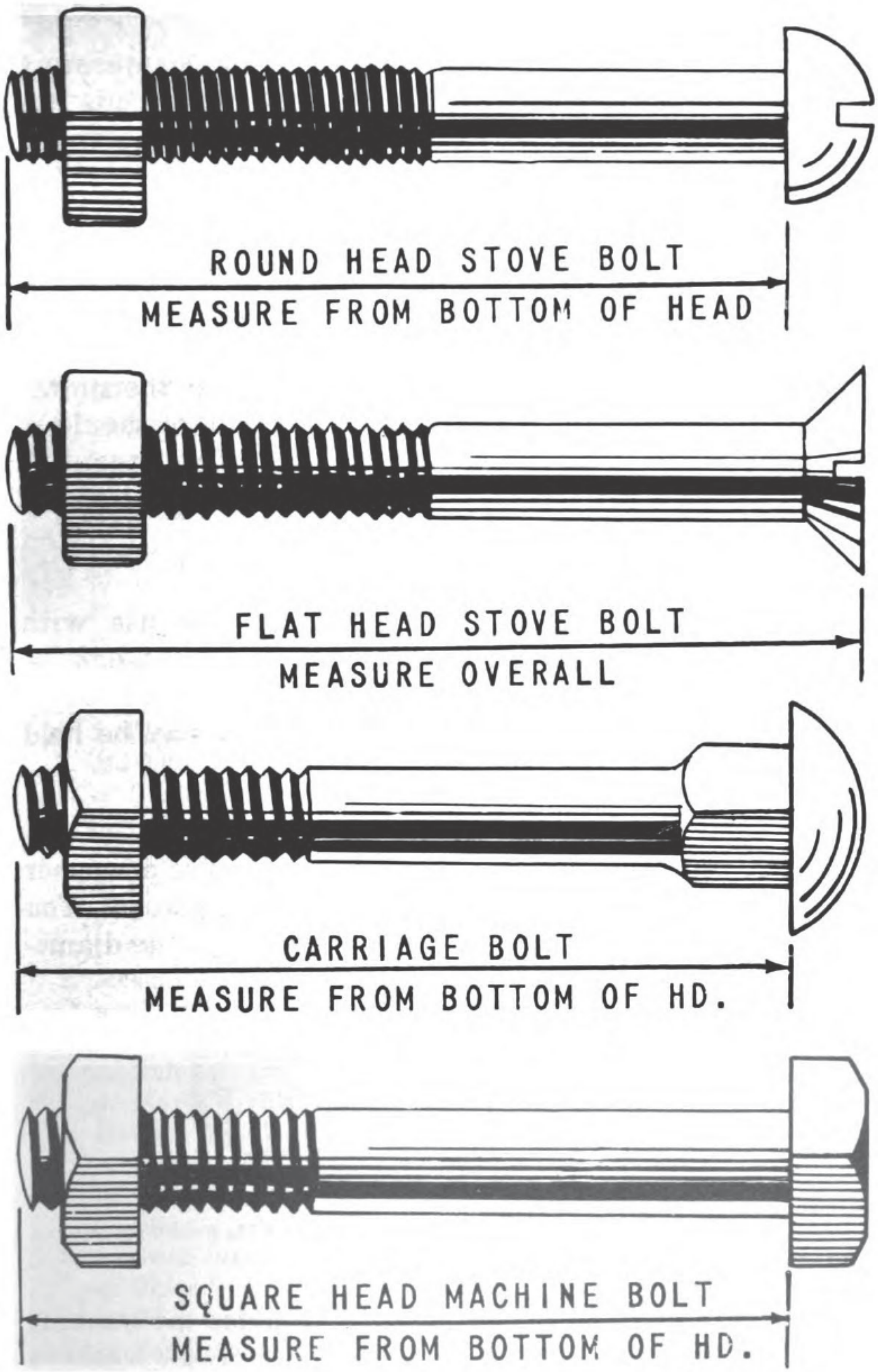
Figure 6–6.—Lag screw.

BOLTS

Bolts are rods with a head at one end and the other end threaded to receive a nut. As fasteners, they provide the strongest method existing to make two pieces of wood material fast. The three types used in building jobs are stove, carriage, and machine bolts. Acquaint yourself with the types and sizes of bolts by studying figure 6–7.

Stove Bolts

Stove bolts are small bolts used for light work. They range in length from ⅜ of an inch to 4 inches, and ⅛ to ⅜ of an inch in diameter. The head of a stove bolt may be round or flat. The round-head stove bolt has a flat shoulder, while the flat-head stove bolt has a tapered



Courtesy of The Bruce Publishing Co.

Figure 6–7.—Bolts.

shoulder. The flat-head stove bolt must be countersunk to make the head flush with the surface. Both heads are equipped with a slot so you can keep the bolt from turning while you tighten the nut.

Carriage Bolts

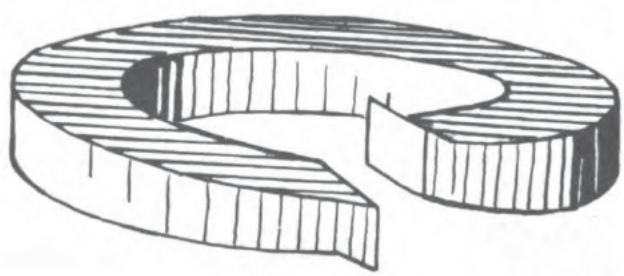
The sizes of these bolts range from $\frac{3}{16}$ to $\frac{3}{4}$ inch in diameter, and from $\frac{3}{4}$ of an inch to 20 inches in length. A carriage bolt is only a partially threaded bolt. It is made with a semiround head, and is flat on the under side to fit against the wood. There is a square shoulder underneath the head to prevent the bolt from turning as the shoulder is drawn into the wood, when you tighten the nut.

Machine Bolts

Machine bolts are designed primarily for use with metal, but they are also used by the builder when he fastens wood and metal materials together. The head of the machine bolt is square so that the bolt may be held with a wrench while you tighten the nut.

Lock Washers

When you use bolts on wood, you should use a washer to prevent the nut from being drawn into the wood. You determine the size of the washer to be used by the diame-



Courtesy of The Bruce Publishing Co

Figure 6–8.—Lock washer.

ter of the bolt over which you desire to place the washer. Washers range in size from $\frac{3}{16}$ inch up. Lock washers (see figure 6–8) are desirable when you fasten wood to metal by means of bolts.

BUILDERS' TOOLS

You, as a builder in the Navy, will have a full set of tools available for your use in construction work. These tools have been carefully selected by the Navy after many years of research with various standard tools. Good tools are desired by all good craftsmen; therefore, pride yourself in the care and proper use of your tools. They will help you to do a good job in the Construction Battalion. You should become familiar with the use of each builder's tool and through actual experience you'll become a skilled Builder. Tools are classified according to use as follows:

1. *Guiding and testing tools.*—
   a. Straight edge.
   b. Square.
   c. Sliding T-bevel.
   d. Miter box.
   e. Level.
   f. Plumb bob.
2. *Marking tools.*—
   a. Chalk line.
   b. Carpenter's pencil.
   c. Ordinary pencil.
   d. Scratch awl.
   e. Scriber.
   f. Compasses and dividers.
3. *Measuring tools.*—
   a. Carpenter's 2-foot rule.
   b. Various folding rules.
   c. Rules with attachments.
   d. Marking gages.
4. *Holding tools.*—
   a. Horses or trestles.
   b. Clamps.
   c. Vises.
5. *Toothed cutting tools.*—
   a. Saws.
   b. Files and rasps.
   c. Sandpaper.
6. *Sharp-edge cutting tools.*—
   a. Chisels.
   b. Drawknife.

7. *Rough facing tools.*—
   a. Hatchet.
   b. Ax.
   c. Adze.
8. *Smooth-facing tools.*—
   a. Spoke shave.
   b. Planes.
9. *Boring tools.*—
   a. Brad awl.
   b. Gimlets.
   c. Augers.
   d. Drills.
   e. Hollow augers.
   f. Spoke pointers.
   g. Counter sinks.
   h. Reamers.
10. *Fastening tools.*—
   a. Hammers.
   b. Screw drivers.
   c. Wrenches.
11. *Sharpening tools.*—
   a. Grind stones.
   b. Abrasives.
   c. Grinding wheels.
   d. Natural oil stones.
   e. Artificial oil stones.

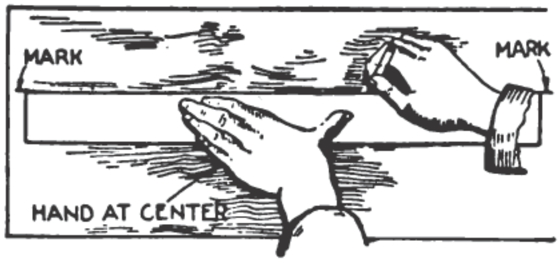
Check your *Basic Hand Tool Skills*, NavPers 10085, and you'll discover that you should already be acquainted with many of the tools classified for use in carpentry. The remaining important tools of the woodworker are introduced and described in the following pages.

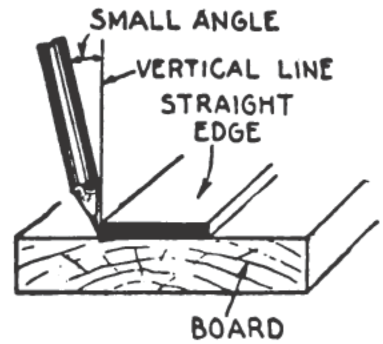
GUIDING AND TESTING TOOLS

Making accurate measurements and fitting wood material together at the required angles are TWO MUSTS in becoming a good carpenter. The straight edge and the miter box are two tools that assure you of this required accuracy.

The Straight Edge

This guiding tool is made from wood or steel and ranges in length from a few inches to several feet. To use this





Courtesy of Theo. Audel & Co.

Figure 6–9.—How to use the straight edge.

tool properly, it is important that you press your hand firmly on the straight edge with your thumb and other fingers spread far apart as indicated in figure 6–9.

Miter Box

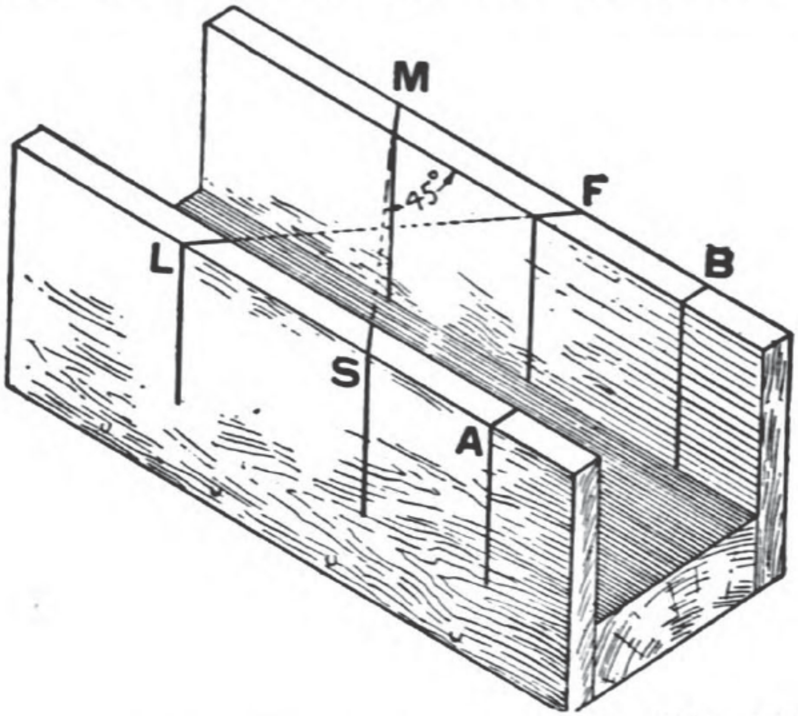
A miter box is a device to make the fitting of two pieces of material, in a miter joint, accurate by guiding the saw in cutting the stock. It is made simply by forming a trough with a bottom and two side pieces of wood, and fastening them together with screws. Saw cuts are then made through the sides at angles of 45 and 90 degrees, as shown in figure 6–10. You'll notice that there are two 45-degree cuts *MS* and *LF*, which are used for cutting right and left miters.

A MANUFACTURED miter box is an adjustable bench-type device designed to make miter cutting very easy. The miter box consists of bed and back, swinging lever, saw guides and posts, length gage, and an angle attachment for less than 45°. The back saw is attached to the swivel arm. By using the miter box and back saw, wood material may be cut at any angle you desire. (See figure 6–11.)

MARKING TOOLS

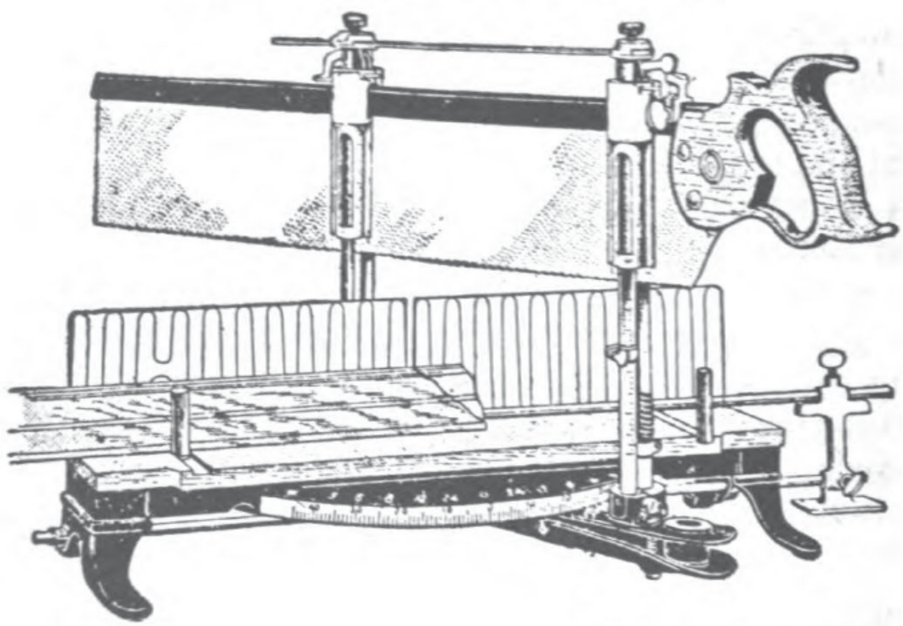
The Builder's skill depends upon his accuracy in marking the work with pencil or scriber and following these

lines in cutting and joining. You select the proper marker to use according to the degree of precision demanded in each operation. For very rough work, you should use the



Courtesy of Theo. Audel & Co.

Figure 6–10.—Forty-five-degree miter box.



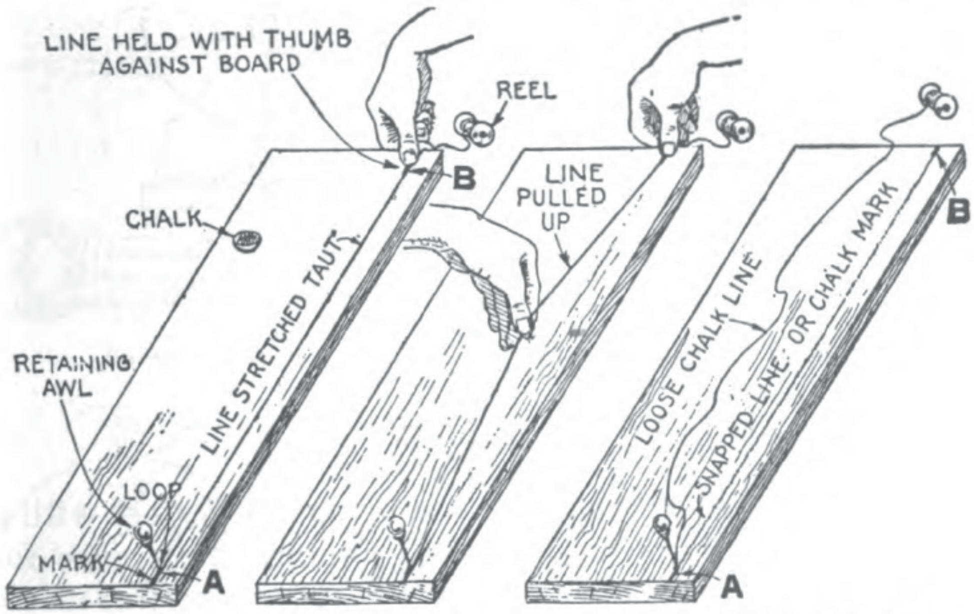
Courtesy of Theo. Audel & Co.

Figure 6–11.—Miter box and back saw.

chalk line and reel and the carpenter's pencil with rectangular lead. The lead pencil with round lead is used for semirough work. For fine joining where precision is the prime requisite, the scratch awl is your marking tool. You'll discover that selection of the proper marking tool is simply good common sense and judgment.

Chalk Line and Reel

When you have two distant points through which a straight line is to be drawn, the chalk line is your marking tool. The line consists of a light string or cord, rubbed with chalk. To use the line stretch it between two points and, with the string taut, pull it up and release it. It



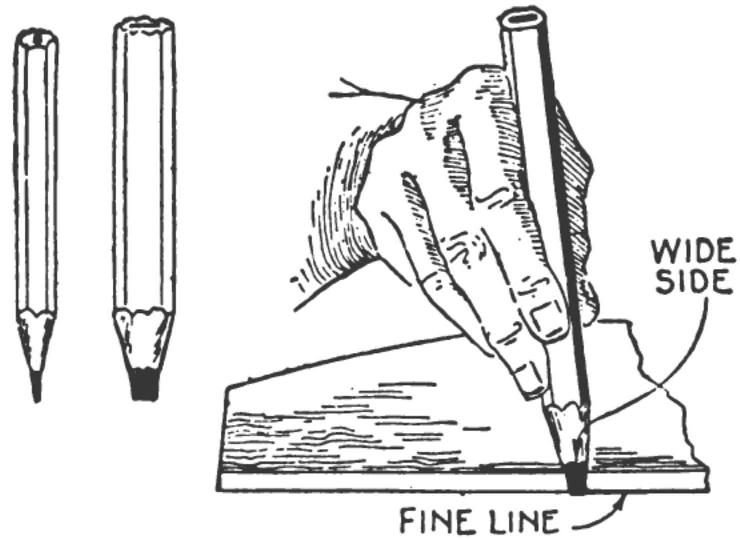
Courtesy of Theo. Audel & Co.

Figure 6–12.—Using the chalk line.

will spring back and make a straight white line on the surface of the material. It is necessary that you pull up the line at right angles to the material to be marked. There is also a trick to handling the chalk in chalking the line. The chalk should be rotated in the palm of the hand while the line is being drawn through in order to eliminate any deep cuts in the chalk. (See figure 6–12.)

Carpenter's Pencil

The carpenter's pencil contains a rectangular lead much larger than an ordinary pencil. The lead is designed for use on rough lumber. The carpenter's pencil is used to mark boards and is not intended for precision work. (See figure 6–13.)



Courtesy of Theo. Audel & Co.

Figure 6–13.—Proper method of sharpening carpenter's pencil.

Scratch Awl

A scratch awl is a short piece of rounded steel with a pointed end fitted into a rounded handle. It is used for laying out lines on wood or metal where a pencil line would be too coarse. Figure 6–14–A.

Pocket Scriber

Figure 6–14–B shows one type of scriber that is also used for laying out lines on wood or metal. Having a longer, sharper point than a scratch awl, it is suitable for finer work requiring greater accuracy. The point is held in a chuck so that it can be removed and inserted with the point inside the handle when stowed. This protects the user and the tool.

Pencil Compass

One leg of the pencil compass in figure 6–14–C is made to hold a short pencil while the other leg is fitted with a steel point. The wing nut permits and maintains adjustment of the legs.

MEASURING TOOLS

You are familiar with the 2- and 6-foot rules, and probably with many other folding rules. Do you know about the boxwood extension rule designed to take measurements such as inside openings of window and door frames? Study Figure 6–15 that shows the boxwood

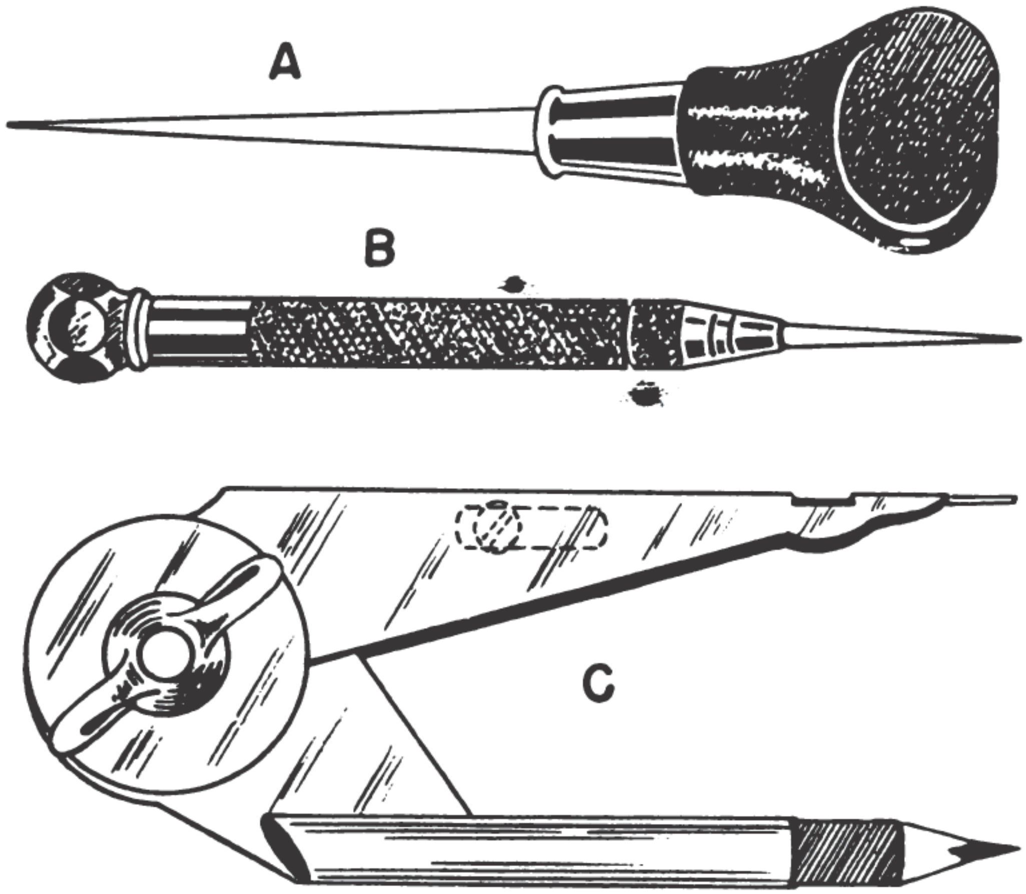
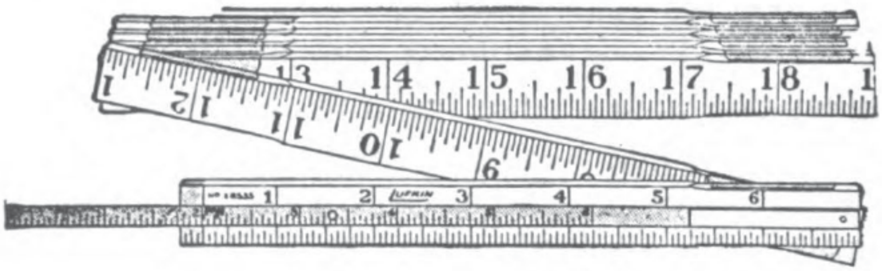


Figure 6–14.—(a) Scratch awl; (b) scriber; (c) pencil compass.

extension rule. Figure 6–16 shows the method for using the extension rule for inside measurements. Open the rule to within 6 inches or less of the distance between the

points to be measured. With the push button, release the brass slide, and extend the slide to the point to be measured. The reading on the brass slide will give you the exact distance between the points measured. After



Courtesy of Theo. Audel & Co.

Figure 6–15.—Boxwood extension rule.

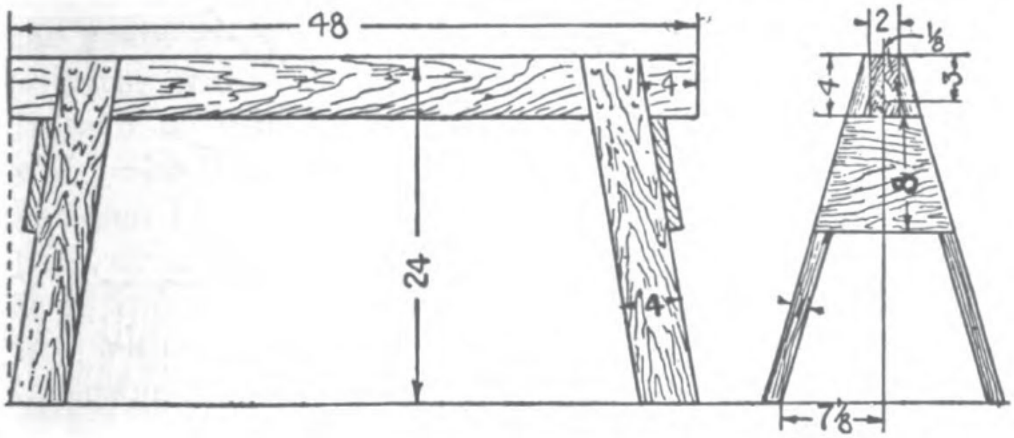
Courtesy of Theo. Audel & Co.

Figure 6–16.—Method of taking inside measurements with the boxwood extension rule.

you have made the measurement, always close the rule. Never leave the rule open on the ground as your shipmates may step on it and break it.

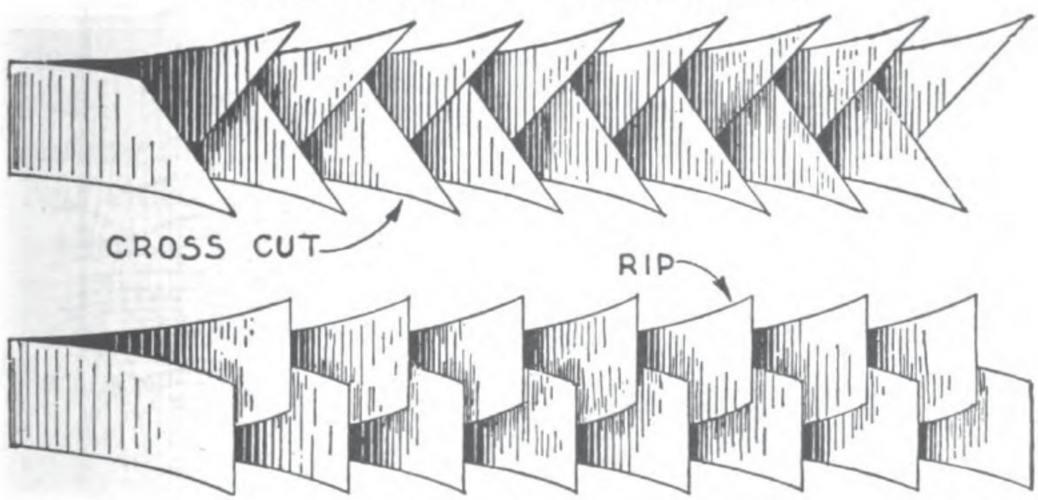
HOLDING TOOLS

In your *Basic Hand Tool Skills*, you became acquainted with clamps and vises to hold work rigid for planing and chiseling. Horses or trestles are used to support the work



Courtesy of Theo. Audel & Co.

Figure 6–17.—Side and end views of saw horses.



Courtesy of Theo. Audel & Co.

Figure 6–18.—Ripsaw and crosscut saw teeth.

while marking or sawing. Horses usually consist of a 4-foot length of 2 x 4 for the cross beam, and a pair of 1 x 4 legs at each end. (See figure 6–17.)

The Saw

The essential toothed cutting tool is the hand saw. Learning to saw properly and keeping the saw in first-class condition will enable you to make sawing, the hardest task of the carpenter, an easier one.

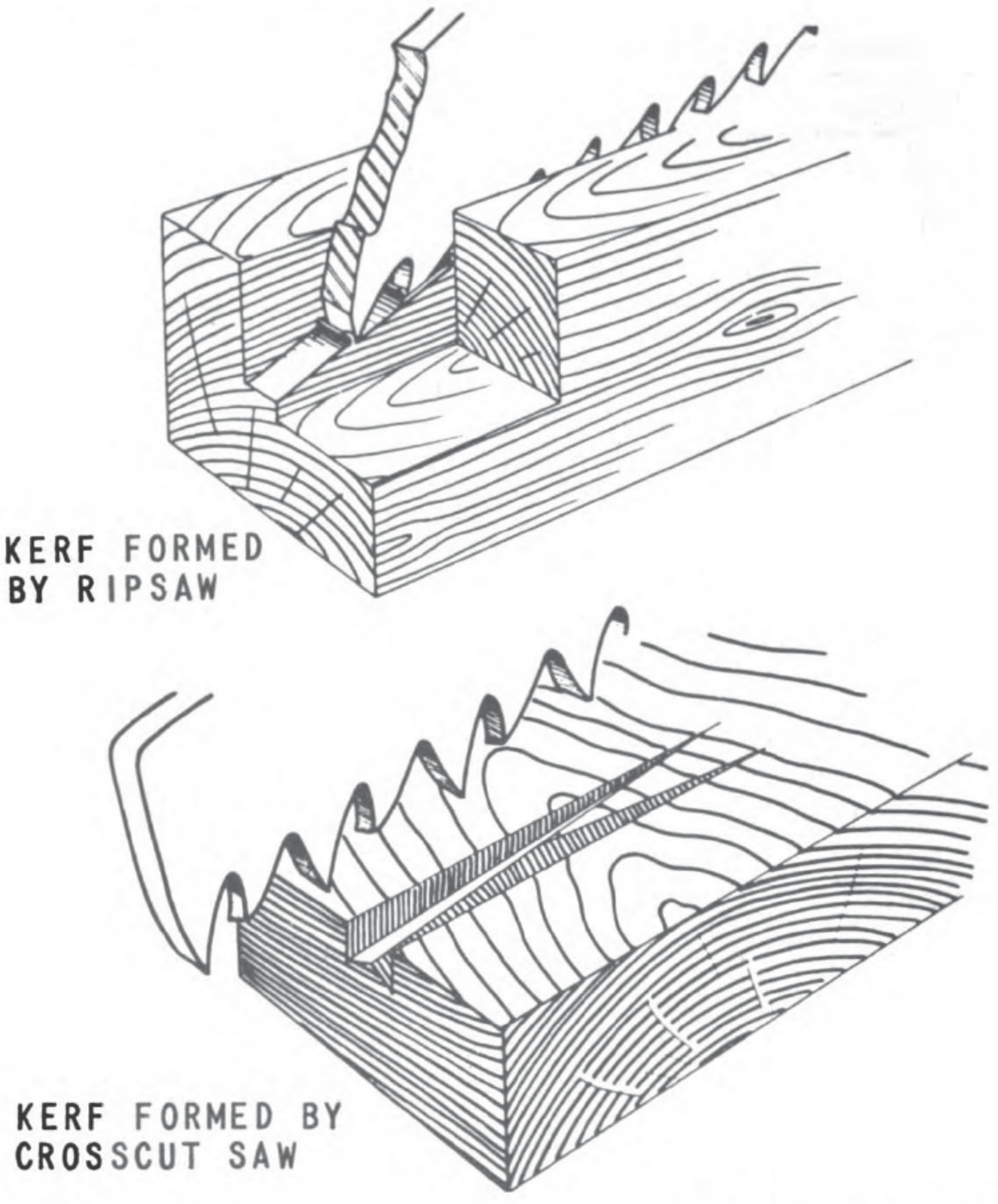


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Figure 6–19.—Difference in formation of kerf made by ripsaw and crosscut saw.

Two commonly used saws, in building operations, are the crosscut saw and the ripsaw. Modern saws are made of the finest tempered steel and in various designs and shapes to meet every particular need. The length of the blade in inches determines the size of a saw. The crosscut saw varies from 20 to 26 inches in length, and has from 8 to 12 teeth per inch. This saw is used for cutting across the grain of wood, as the teeth clog easily when cutting with the grain. The ripsaw, generally 26 inches long with from 5 to 8 teeth to the inch, is designed for cutting wood with the grain. Figure 6–18 indicates the difference between ripsaw teeth and the crosscut-saw teeth. The path, or KERF, formed by the cutting actions of these two saws is formed differently (see figure 6–19). A crosscut saw with a stiff back is used for fine-finish work and in the miter box.

SHARP-EDGE CUTTING TOOLS

The success of your job as a Builder, depends a good deal on keeping your tools sharp, clean, and free from rust. The slick chisel is the only one of the sharp-edged cutting tools not discussed in your *Basic Hand Tool Skills*. Any chisel, having a blade wider than 2 inches is termed a slick. The slick chisel is adapted for use on large wood surfaces where you desire to take off considerable material. It may be used with a mallet or simply with your hands.

ROUGH-FACING TOOLS

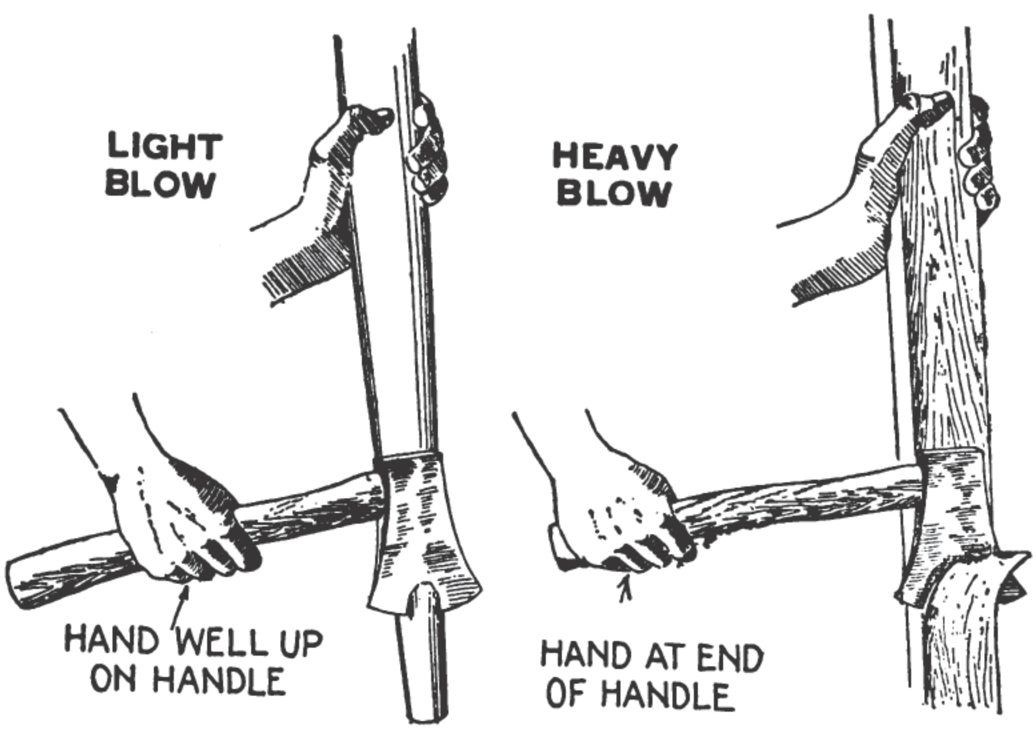
The half hatchet, hand ax, and the adze are termed rough-facing tools because the cut made is rough compared to that made by other tools. They are also known as striking tools because the work is done by a series of blows.

The Half Hatchet

You are probably familiar with this general utility tool. In framing timber, it may be used as a hammer, for sharpening stakes, or cutting timber to rough size. For lathing and shingling, it is used as a combination hammer and cutting tool. The half hatchet is also useful for splitting wood. Always keep the cutting edge of your rough-cutting tools in proper condition—there should not be a single nick in the edge.

Hand Ax

A large hatchet (see figure 6–20) with a broad cutting edge is called a hand ax. In order to make a light blow with the hand ax, you place your hand well up on the handle. When you desire to make a heavy blow, place your hand at the end of the handle.



Courtesy of Theo. Audel & Co.

Figure 6–20.—How to use the hand ax.

Adze

This rough-cutting tool is commonly known as the foot-adze. You'll use the adze for hewing or smoothing lumber or logs where a lot of wood is to be removed. This adze is a form of hatchet on which the edge of the blade is at right angles to the hatchet. The handle is curved to provide the proper angle for cutting and also to give balance to the adze.

Figure 6–21.—How to use the adze.

The adze is a two-handed cutting tool. The hands should be placed 12 to 15 inches apart on the handle and held in front of the body. You should straddle the timber to be hewed when using the adze (see figure 6–21). The timber must be held fast, not allowed to slide or roll. Chips should be kept clear of the cutting edge as they may cause the adze to change its course and perhaps cause serious injury by cutting your leg or foot.

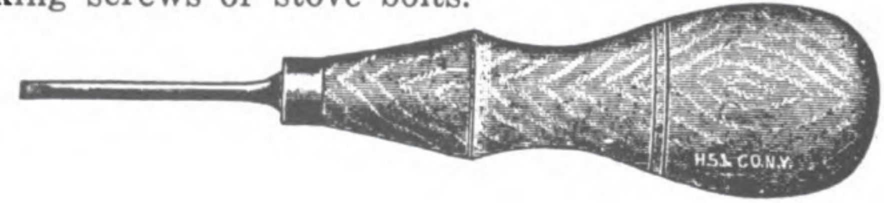
Never use the adze for driving a stake or as a prying tool. When not in use, it should be oiled and stored so as to protect the cutting edge.

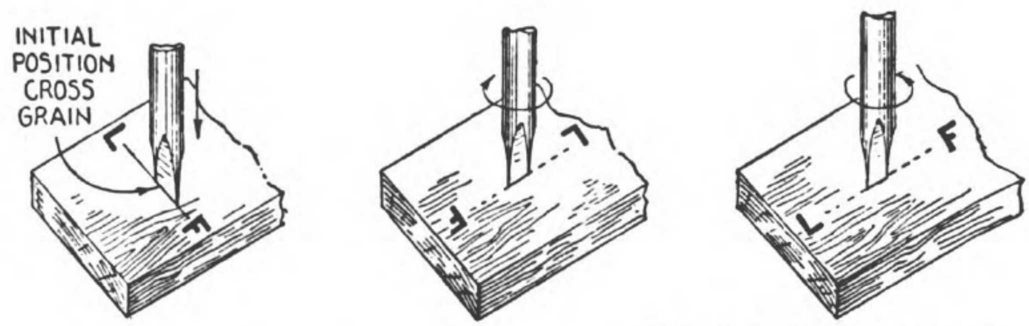
The blades of the rough-cutting tools are sharpened by

means of a grinding wheel and an oil stone. Care should be taken to keep the blade from overheating while it is being ground.

BORING TOOLS

Boring tools are used to cut holes of various sizes in wood. They are also used for reaming and for countersinking screws or stove bolts.





Courtesy of Theo. Audel & Co.

Figure 6–22.—Method of using the brad awl.

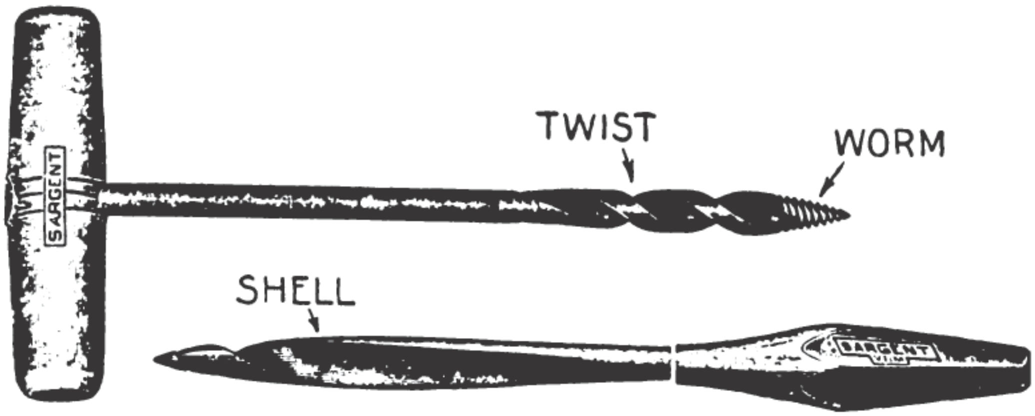
Brad Awl

A brad awl is a tool with a point for piercing small holes. It has an edge similar to a screw driver, and may be used to drive small screws. You'll use the brad awl for making holes in order to start a nail or screw into hard wood. The proper method for using the brad awl is to start with the edge of the tool across the grain of the wood. When you force the awl into the wood, do not turn the tool completely around, but turn it alternately in both directions. (See figure 6–22.)

Gimlets

These tools are designed for boring small holes by hand pressure. Two kinds of gimlets are available—the twist and the shell gimlet. Figure 6–23 shows both types.

When you use the gimlet, grasp the handle with the right hand and press the tool into the wood with the palm of your hand. Drive the gimlet into the wood by making half turns, releasing and regrasping the handle at each half turn.



Courtesy of Theo. Audel & Co.

Figure 6–23.—The twist and shell gimlets.

Augers

You'll utilize augers for boring holes from ½ inch to 2 inches. Their sizes are listed in 16ths, therefore

Figure 6–24.—Six types of auger bits.

a 2-inch auger would be listed as size 32. When augers are made with a shank, for brace use, they are called bits. The auger bit consists of five parts; namely, the shank which fits into the brace, the body which may have either a single or a double twist, the nibs which cut the fibers of the wood around the circumference of the hole, the lips which cut and lift up the shavings, and the spur, which, with its threads, assists in pulling the bit into the wood to start the cutting operation.

The bits most frequently used in building operations are auger, Forstner, gimlet, plug, ship-auger, and expansion bits. Figure 6–24 pictures these six types of bits.

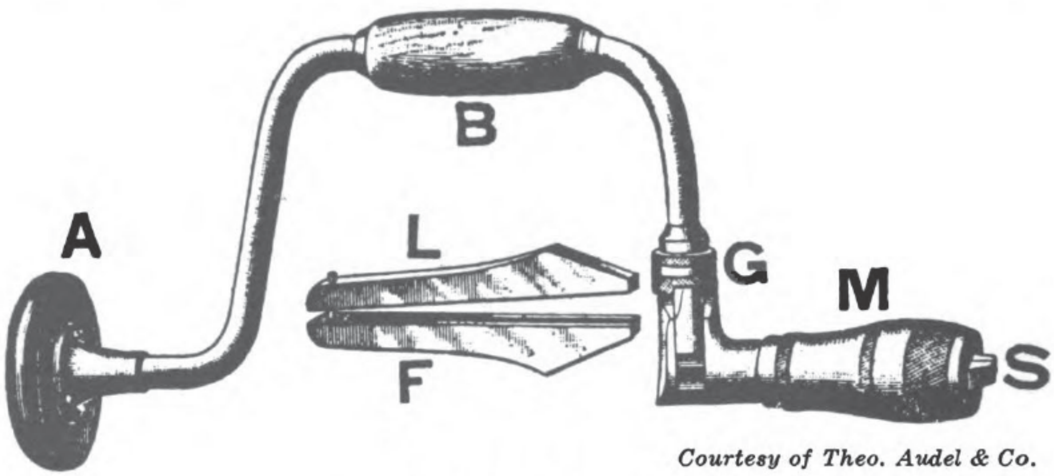


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Figure 6–25.—Ratchet brace.

Bear in mind that all boring tools are called bits when they are provided with a shank for use with a brace instead of a handle.

The RATCHET brace is generally used for holding bits. Figure 6–25 indicates the parts of the ratchet brace. The jaws *LF* are held fast in the screw sleeve *M*, and are adjustable. The projecting ends from the sleeve at point *S* hold the bit. *A* is the cap which turns loosely on the end of the brace. You'll be able to guide the auger by holding the cap in the left hand, and running the brace with the other hand. The ring *G* is provided so that the ratchet may be adjusted for right or left release.

YOU'RE NO BETTER THAN YOUR TOOLS

Just remember that no Builder can be any better than his tools. It's not the original cost of tools that counts, but the way they are kept. Keep them clean, keep them oiled, keep them sharp, and you'll be sharp.

QUIZ

1. In reference to shape, how are nails classified?
2. In reference to size, nails are classified into three major groups. Name them.
3. Nails are also classified according to the type of construction in which they are used. Name these six groups.
4. How are spikes used in heavy construction work?
5. What is the rule to follow in selecting the proper sizes of nails for building jobs?
6. Name the standard screws.
7. What is a lag screw?
8. Bolts as fasteners are the strongest for making two pieces of wood material fast. What are the three types used in building jobs?
9. When you use bolts on wood, why should you use a washer?
10. When are lock washers desirable?
11. Describe the device known as a miter box.
12. What marking tool should you use for fine joining where precision is the prime requisite?
13. For what measurements is the boxwood extension rule designed?
14. How are the blades of the rough-cutting tools sharpened?
15. Boring tools are used to cut holes of various sizes in wood. Name two other uses.
16. For what is the brad awl used?
17. What two kinds of gimlets are available?
18. How is the gimlet driven into the wood?
19. Name the six types of bits most frequently used in building operations.

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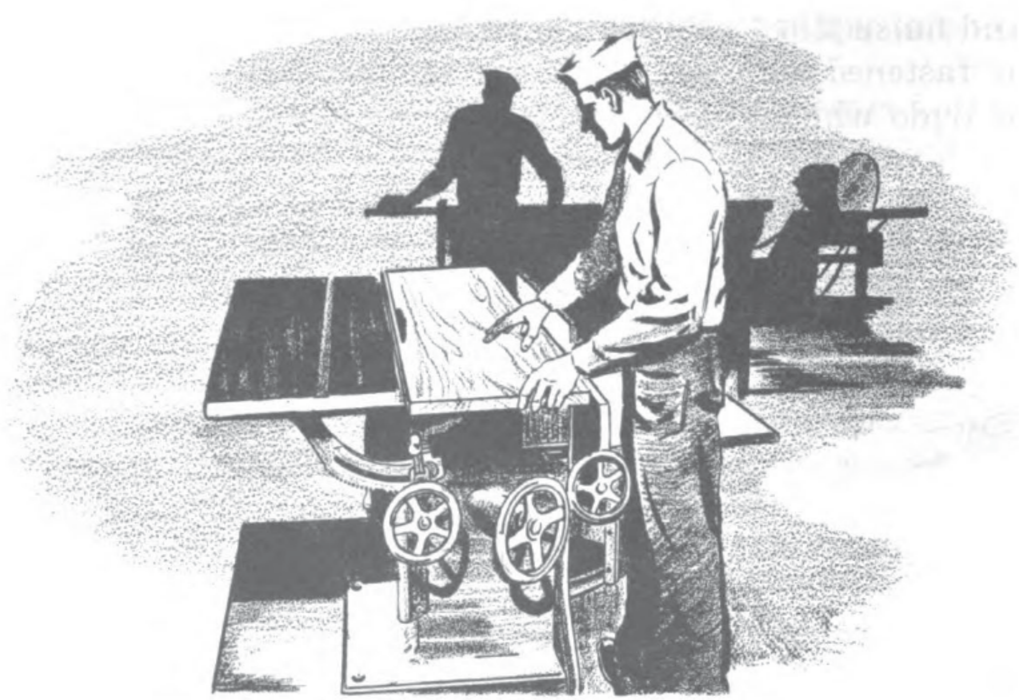


CHAPTER 7

POWER TOOLS

CIRCULAR SAWS

When power equipment is being installed for woodworking, the first machine to be considered is the circular saw. With one of these machines you can do work in minutes that would take you hours to do by hand. If you are a Builder on a naval base, whether in the States or overseas, you will probably have a good circular saw in the carpenter shop.

Many varieties and sizes of saws are available, but all are designed principally to cross-cut and rip wood. In addition, such jobs as dadoing, rabbeting, splining, and tenoning, are easily done on the circular saw.

The plain *dado* joint is often used in making cabinets and shelves. It is usually cut with a dado head (cutter) which fits the mandrel of a circular power saw. You can also make this cut by hand with a backsaw or tenon saw

and finish it with chisels. This joint may be glued, nailed, or fastened with screws. The gain joint is a special kind of dado which is used when appearance is an important

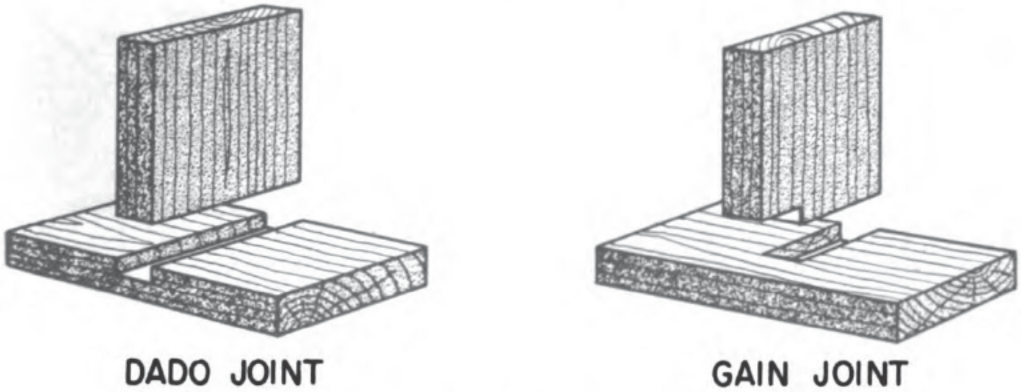


Figure 7–1.—Dado and gain joints.

factor. Otherwise you can use it much the same as the plain dado. Dadoes and gains are both cut across the grain of the wood. (See figure 7–1.)

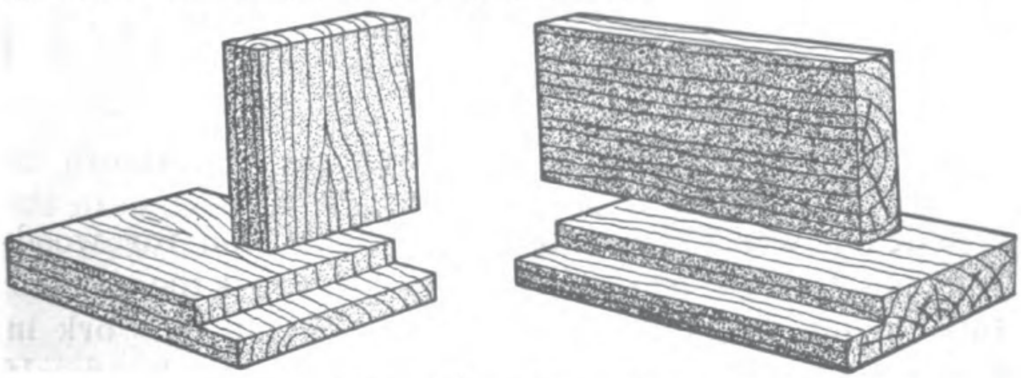


Figure 7–2.—Rabbet joints.

RABBET joints are often used in conjunction with dadoes. They may be cut either across the grain or with the grain (see figure 7–2).

Rabbets can be made with the circular saw dado head (or blade) or, to a more limited extent, with the jointer. They can also be cut by hand with special rabbeting planes.

A SPLINE is a small wooden strip inserted in a slot or groove between parts of two pieces of wood to join them together. This type of glued joint is an excellent means

of securing wood furniture material together. It is particularly useful in making table tops and picture frames. (See figure 7–3.)

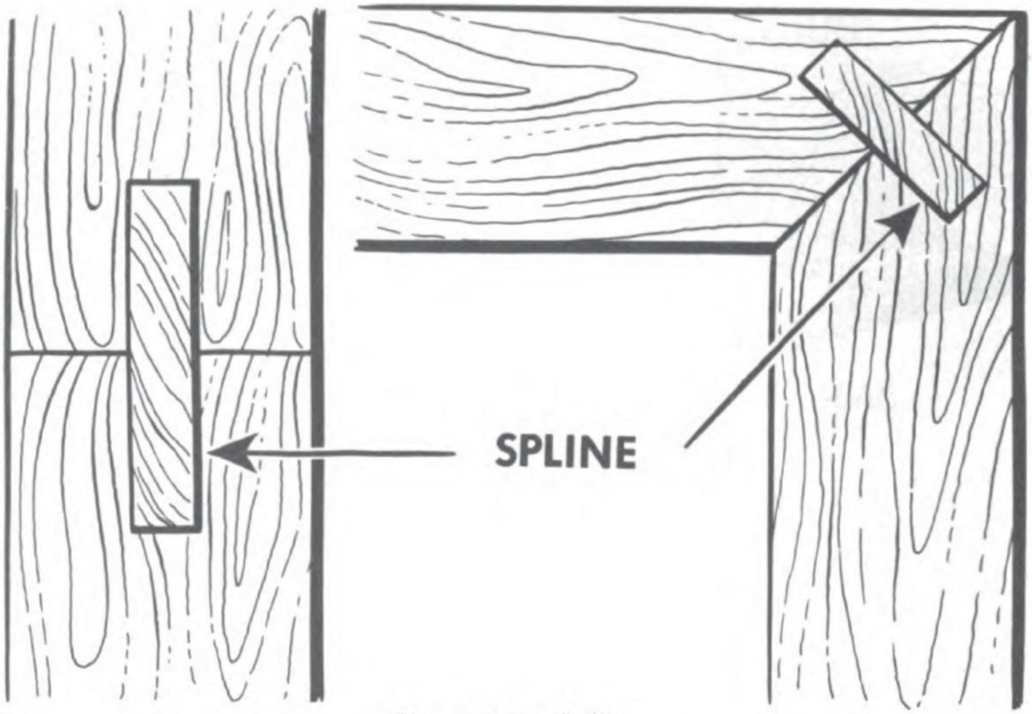


Figure 7–3.—Spline.

A MORTISE-AND-TENON joint, like the one shown in figure 7–4, consists of an opening called a mortise in the side of one piece, into which fits the specially shaped end or "tenon" of the other piece. The tenon may be fastened into the mortise by means of a wood or steel pin. Good furniture usually is made with a number of mortise and tenon joints.

A light-duty circular saw is pictured in figure 7–5. This machine carries a 10-inch blade mounted on a tilting shaft which makes it unnecessary to tilt the table of the saw to make certain angle cuts. The CRANKWHEEL shown at the left is turned to change the angle of the saw blade with the table top. The angle is indicated on the SCALE at the front. The FRONT CRANK is turned to change the "depth of cut" adjustment of the blade. LOCKING KNOBS on each crankwheel are provided to secure the adjustment once it is established.

The RIPPING FENCE, shown on the SAW TABLE at the right, can be used on either side of the blade for ripping, rabbeting, grooving, tenoning, and other operations.

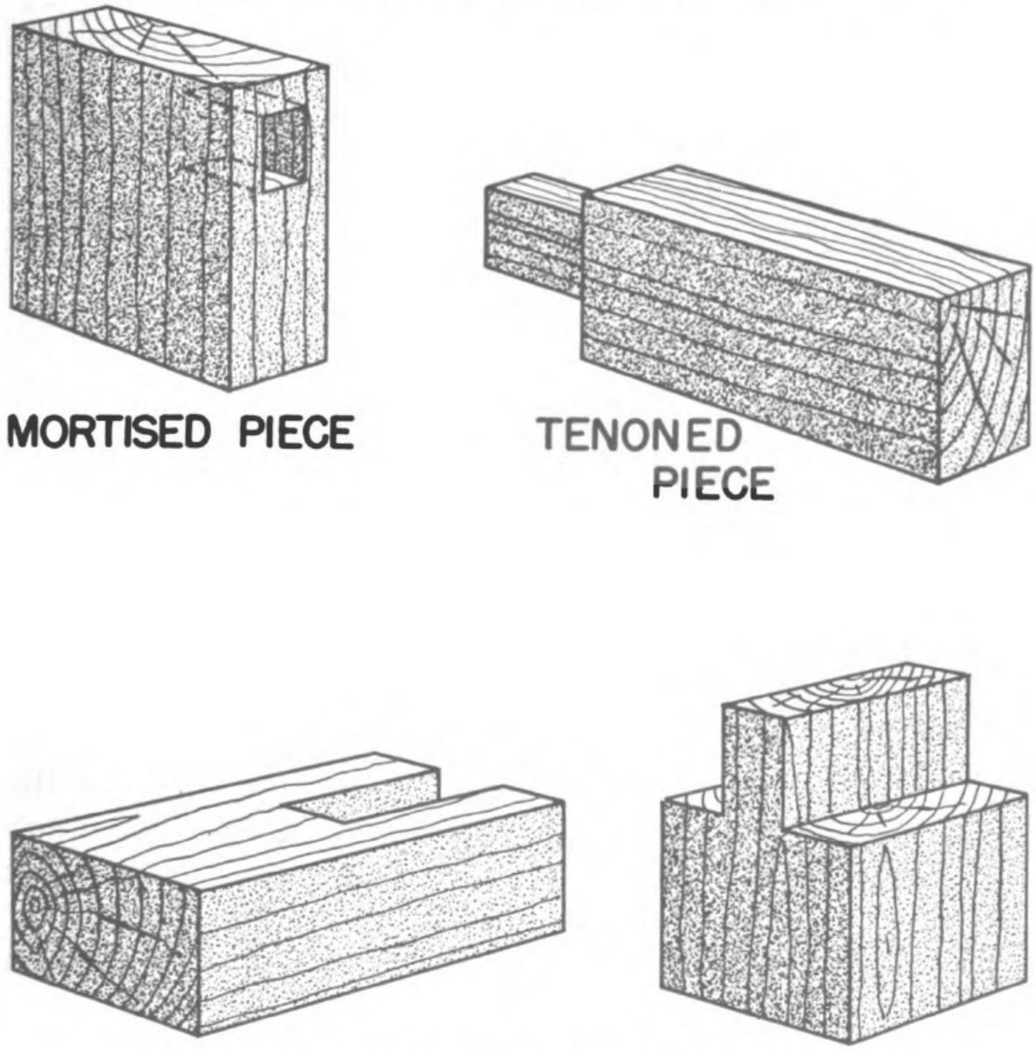


Figure 7–4.—Mortise and tenon.

Avoid dropping or springing this fence—it must be kept parallel to the saw blade. The SLIPPING CUT-OFF GAGE is shown on the table at the left. It is used for crosscutting, mitering, tenoning, and dadoing. The RODS attached to this gage at the left serve as a guide for length in cutting duplicate pieces.

The blade SAFETY GUARD, secured at the back center of the table, covers the blade and provides a KERF (cut) SPLITTER for ripping. The guard prevents the kerf from closing and jamming the blade. Also incorporated in this assembly is a mechanism which prevents pieces going through from being kicked back toward the operator by the fast-moving blade.

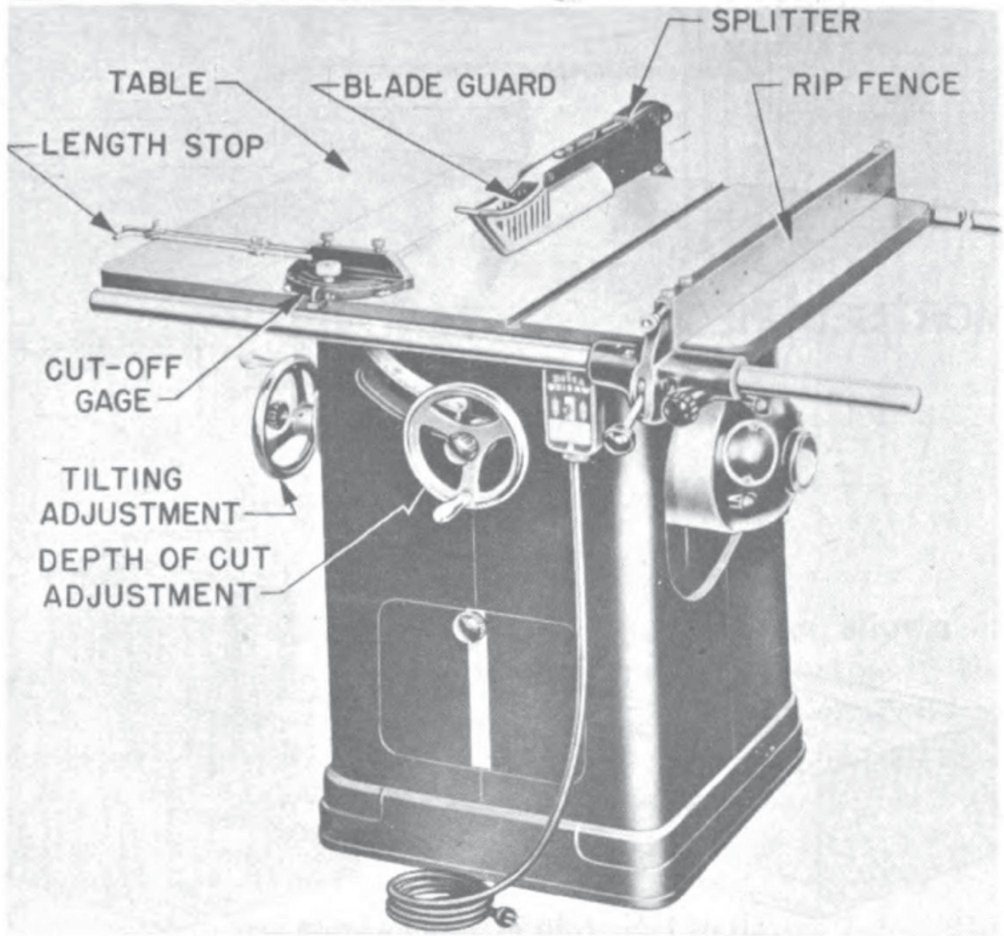


Figure 7–5.—Light-duty, tilt-arbor circular saw.

It's a very good idea NOT to remove the saw guard unless it is impossible to make the desired cut with it in place. The guard won't protect your fingers if it is hanging on the bulkhead or is stowed in a locker. Use it—and the chances will be better that you'll always have five fingers on each hand.

A heavier bench saw is pictured in figure 7–6. This

machine carries a 14- or 16-inch blade and is usually powered with a 3- to 5-horsepower electric motor. The saw shown has a tilting arbor, a rolling or sliding left table for cut-off work, and a ripping fence with an adjustable micrometer.

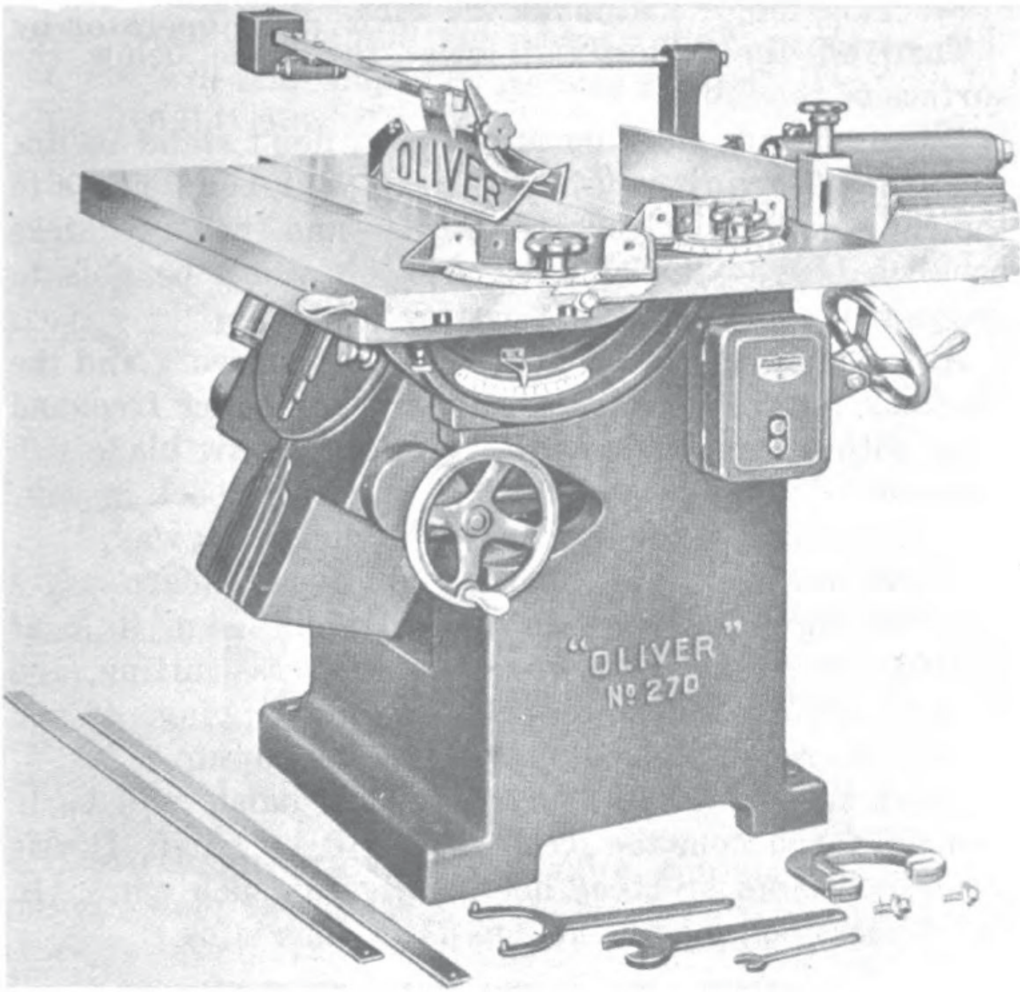


Figure 7–6.—A 16-inch circular bench saw.

Circular Saw Operation

The usual procedure for using the circular saw is as follows:

Be sure you have good footing before you turn on the switch. This includes clearing the deck of chips, blocks, and sawdust. Usually some type of non-skid surfacing material is applied to the deck on the area where the operator normally stands.

Clear the saw table of scrap wood, sawdust, and tools.

Make the depth-of-cut adjustment and see that the guard is in place.

Set the cut-off gage or rip fence.

Check all measurements.

Start the motor and make the cut.

Turn off the motor and lower the blade below the surface of the table.

When you are working at the saw, don't stand in line with the revolving saw blade—keep your body either to the right or left. If you are in line—and the saw "kicks back" a board—the chances are you won't be able to dodge fast enough to avoid getting hit.

Always use the cut-off gage for cross-cut work and the rip fence for rip work. Don't attempt any fancy freehand stuff with a circular saw. If you do, the saw blade will probably bind, grab, stall, or kick the board back in your face. Freehand work wouldn't be accurate anyway.

Avoid sawing pieces that do not have square edges and flat faces. Always have a straight edge to bear against the cut-off gage when you are cross-cutting, and to bear against the fence when you are ripping. If you do have to saw a cupped piece, place the cup up.

Don't saw pieces so short that your hands will be in danger if you hold the piece or feed it by hand. Devise a special clamp or other holding jig for such work. In many cases you may be able to use a push stick.

Circular Saw Safety

Circular saws are designed and built for maximum safety. All moving parts except the blades are fully enclosed, and the blade is well protected by the guard. So, if you do have an accident, it will probably be either because you are careless, or because you do not understand the proper methods of operating the machine. Here are some of the things to remember when you are using a circular saw.—

Set the saw for the proper depth of cut for EACH JOB.

Allow the blade to protrude ONLY $\frac{1}{8}$ inch through the stock.

Keep saw blades CLEAN. Don't allow gum or rosin to accumulate on the blade.

NEVER USE A DULL SAW or one that lacks set or clearance. A dull blade will not make a clean, accurate, fast cut, but will tear and burn its way through slowly.

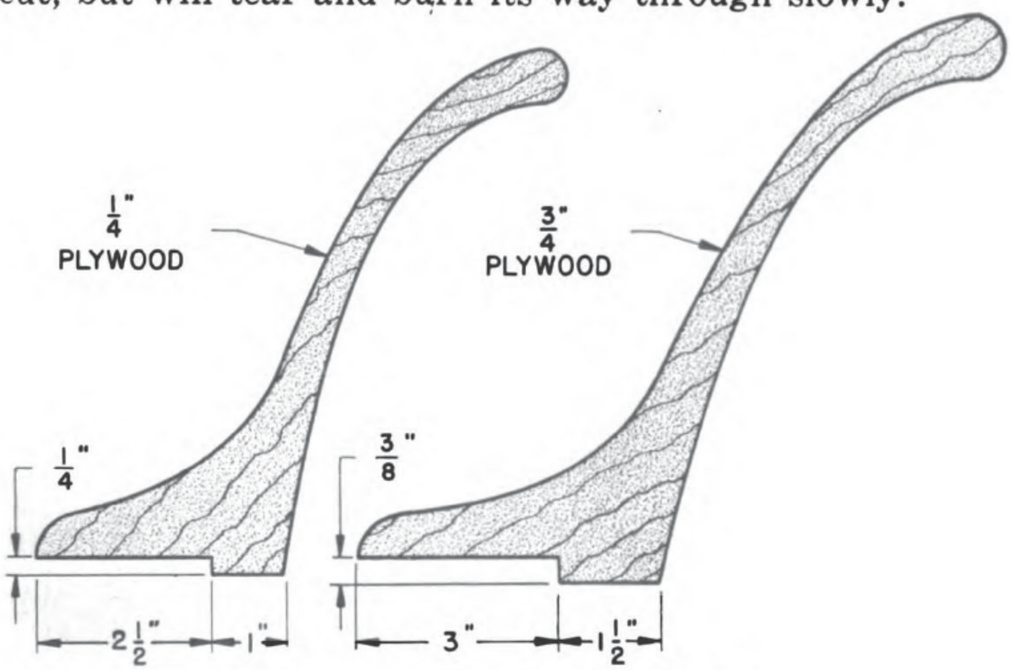


Figure 7–7.—Use push sticks for ripping.

Use a PUSH STICK when you're ripping off narrow pieces. Keep two sticks near the saw, one made of $\frac{3}{4}$-inch stock for regular use and one made of $\frac{1}{4}$-inch plywood that will clear the guard when you are ripping exceptionally narrow pieces. It is also a good practice to attach a piece of plywood of the same size as the ripping fence to it. This will eliminate any possibility of the circular saw colliding with the metal surfaces of the ripping fence. Never rip a narrow piece without using a push stick. Take a look at figure 7–7.

Don't adjust the ripping fence or the cut-off gage while the blade is revolving.

Keep the saw table clear of scrap stock. Remove scrap with the push stick—not with your hands.

Never reach across the saw blade FOR ANY REASON—if your foot slips, you may be thrown across the saw.

Do not use the rip fence as a cut-off stop—always have clearance between the end of the stock and the fence.

Cut off the motor when you have finished using the saw. If the machine is not going to be used again immediately, lower the blade below the surface of the table.

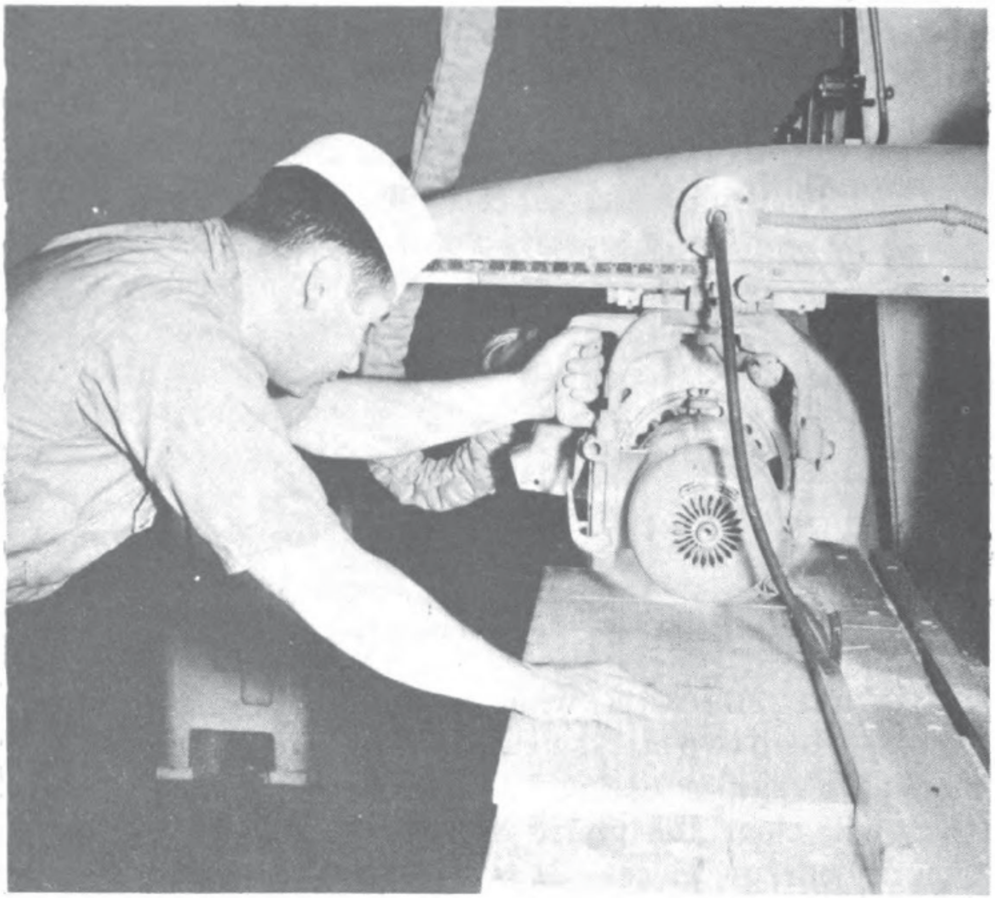


Figure 7–8.—Radial saw in use.

RADIAL SAWS

A radial saw (see figure 7–8) is a circular saw that is mounted above the working table. The saw is usually mounted directly on the motor shaft or arbor and the whole assembly is pulled across the board for cross-

cutting. For ripping, the entire assembly is pivoted 90 degrees and the piece to be cut is fed along the fence past the blade. The table of the radial saw is long and narrow in contrast to the almost square table of a circular bench saw.

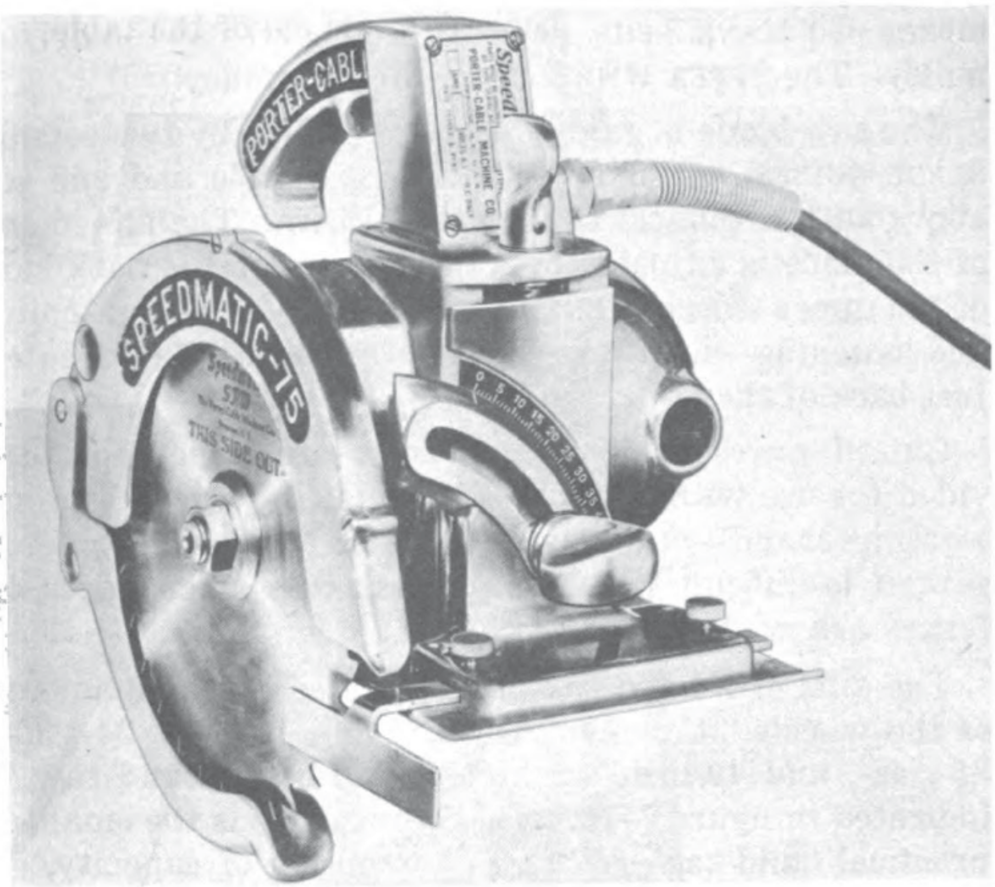


Figure 7–9.—Hand-held circular saw.

For sawing "on the job," you may use a hand-held circular saw, generally known as a skill saw. (Refer to figure 7–9.) This saw is adequate for quick, rough work, such as cutting subflooring or roof sheathing material, but it isn't used for fine work.

BAND SAW

While the band saw is designed primarily for making curved cuts, it can also be used for straight cutting. Un-

like the circular saw, though, the band saw is frequently used for freehand cutting.

The band saw has two large wheels on which a continuous saw blade or BAND turns, just as a belt is turned on pulleys. The LOWER WHEEL is located below the WORKING TABLE, which is connected to the motor directly or by means of pulleys, belts, or gears, and serves as the driver pulley. The UPPER WHEEL is the driven pulley.

The saw blade is guided and kept in line by two sets of BLADE GUIDES, one fixed set below the table and one set above with a vertical sliding adjustment. The alinement of the blade is adjusted by a mechanism on the back side of the upper wheel. TENSIONING of the blade—tightening and loosening—is provided by another adjustment located just back of the upper wheel.

Cut-off gages and ripping fences are sometimes provided for use with band saws, but you'll do most of your work freehand—with the table clear. With this type of saw, it is difficult to make accurate cuts when gages or fences are used.

The SIZE of a band saw is designated by the diameter of the wheels. Common sizes are 14-, 16-, 18-, 24-, 30-, 36-, 42-, and 48-inch machines. A 14-inch band saw is indicated in figure 7–10. The 14-inch size is the smallest practical band saw. With the exception of capacity, all band saws are much alike in regard to maintenance, operation, and adjustment.

Blades or bands for band saws are designated by POINTS (tooth points per inch), THICKNESS (gage), and WIDTH. The required length of a blade is found by adding the circumference of one wheel to twice the distance between the wheel centers. Length can vary within a limit of twice the tension adjustment range. Blades are set and filed much the same as with a hand rip saw.

Here are some safety pointers to keep in mind when you're operating a band saw. Keep your fingers away

from the moving blade. Keep the table clear of stock and scraps so your work won't catch as you push it along. Keep the upper guide just above the work—not exces-

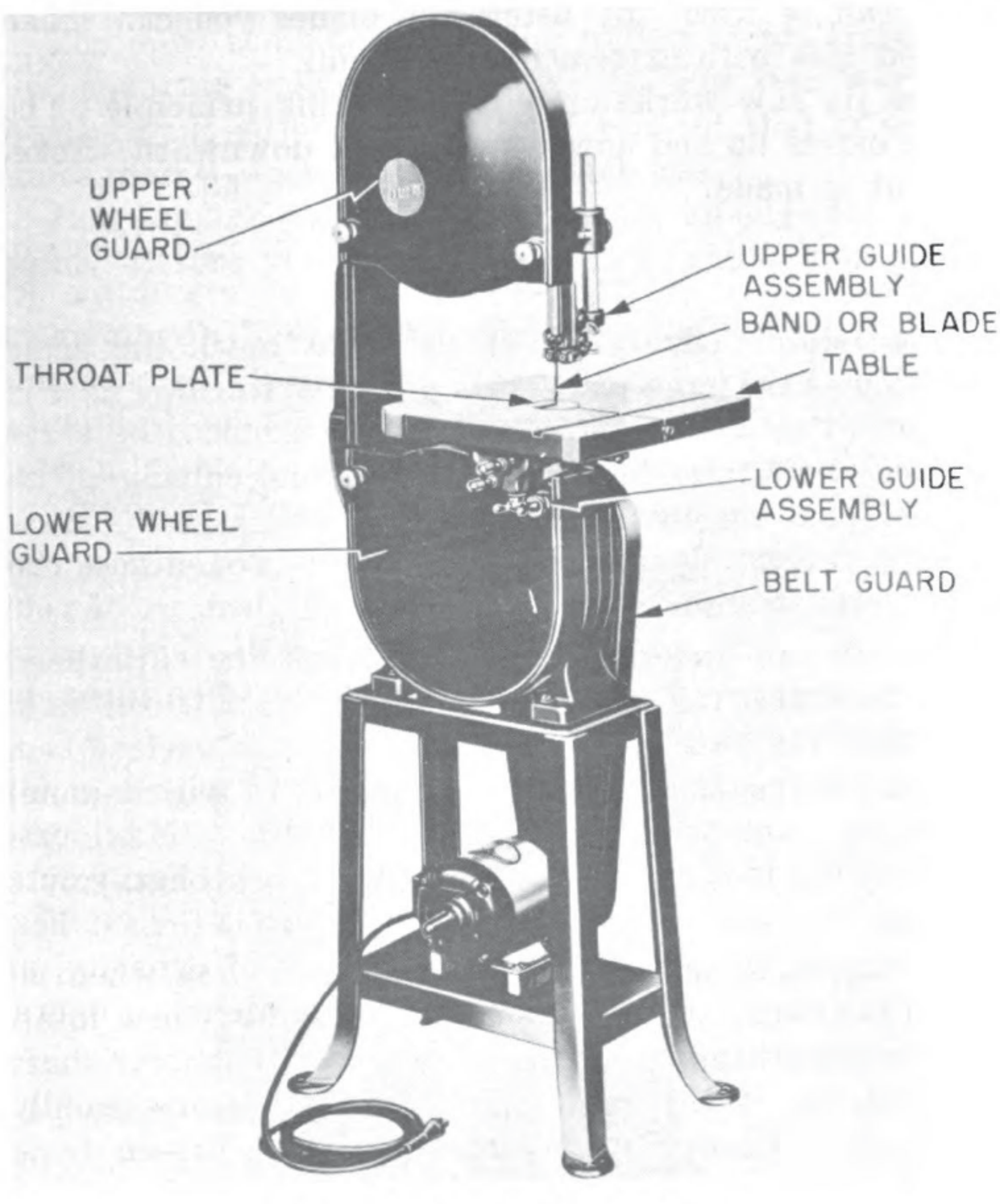


Figure 7-10.—A 14-inch band saw.

sively high. Don't stand to the right of the machine while it is running, and don't lean on the table at any time. Never leave a band saw with the blade in motion. Always apply the pedal brake until the drive wheel has stopped completely.

JIG SAWS

A jig or scroll saw does about the same work as a band saw, but is capable of finer work. A wide range of blade sizes can be used. By using fine blades you can make curved cuts with extremely small radii.

The jig saw works on a reciprocating principle. The blade moves up and down, and, on the downward stroke, the cut is made.

JOINTER

The jointer (figure 7–11) performs much the same function as the hand plane. Its principal working part is the revolving round CUTTERHEAD which holds the three or more KNIVES or bits that do the actual cutting. The knives remove controlled amounts of wood from the stock as it is pushed along the front (infeed) bed, across the cutterhead, and on to the back (outfeed) bed.

As you can understand, the knives of the cutterhead must be PERFECTLY alined and their circle of travel must be PERFECTLY TANGENT to the surface of the outfeed bed. You can adjust the infeed bed up-and-down with a handwheel or crank to control the DEPTH OF CUT. Maximum depth of cut is usually 3/8 or 1/2 inch, but such heavy cuts are seldom made.

A SLIDING GUARD covers the cutterhead area when no board is directly over the cutterhead. On most new jointers the cutterhead is mounted directly on the motor shaft and rotates at the same speed as the motor—usually 3,450 rpm. Light duty jointers often are driven by a V-belt from a motor mounted under the beds of the machines. Older jointers may have flat-belt drives.

The SIZE of a jointer is designated by the WIDTH OF THE CUT the machine can make; 6-, 8-, and 12-inch jointers are the sizes usually found in the Navy shops.

Each jointer has a FENCE which should be used to guide your work and to maintain the desired angle. The fence

is adjustable so you can use it as a guide for cutting chamfers and bevels.

Jointer Operation

The most common use of the jointer is for truing up and squaring edge and face surfaces. For such work the depth-of-cut adjustment is set for a cut that is seldom more than $\frac{1}{16}$ inch and is often much less.

Just suppose you're going to square an edge for a glue joint. Before you throw the switch, check your depth

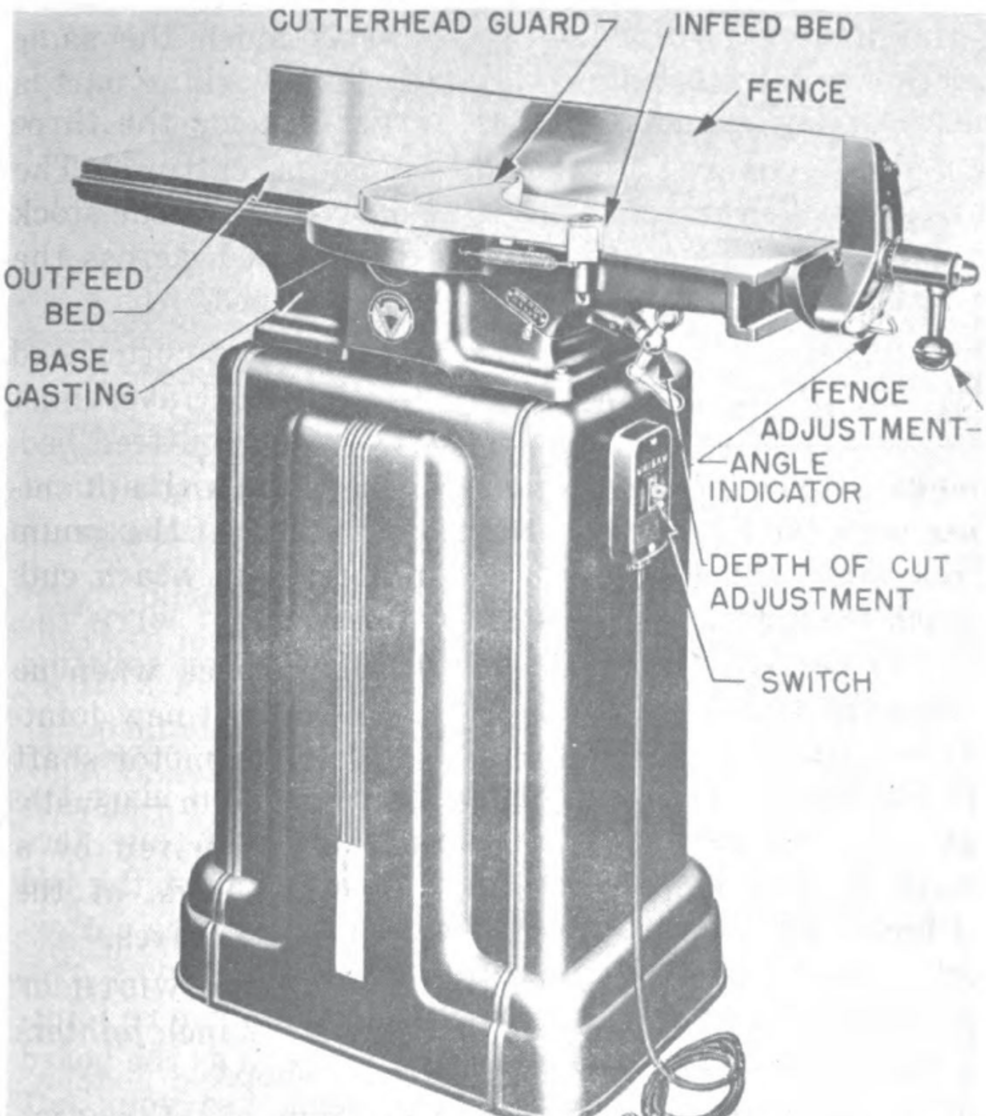


Figure 7–11.—A 6-inch jointer.

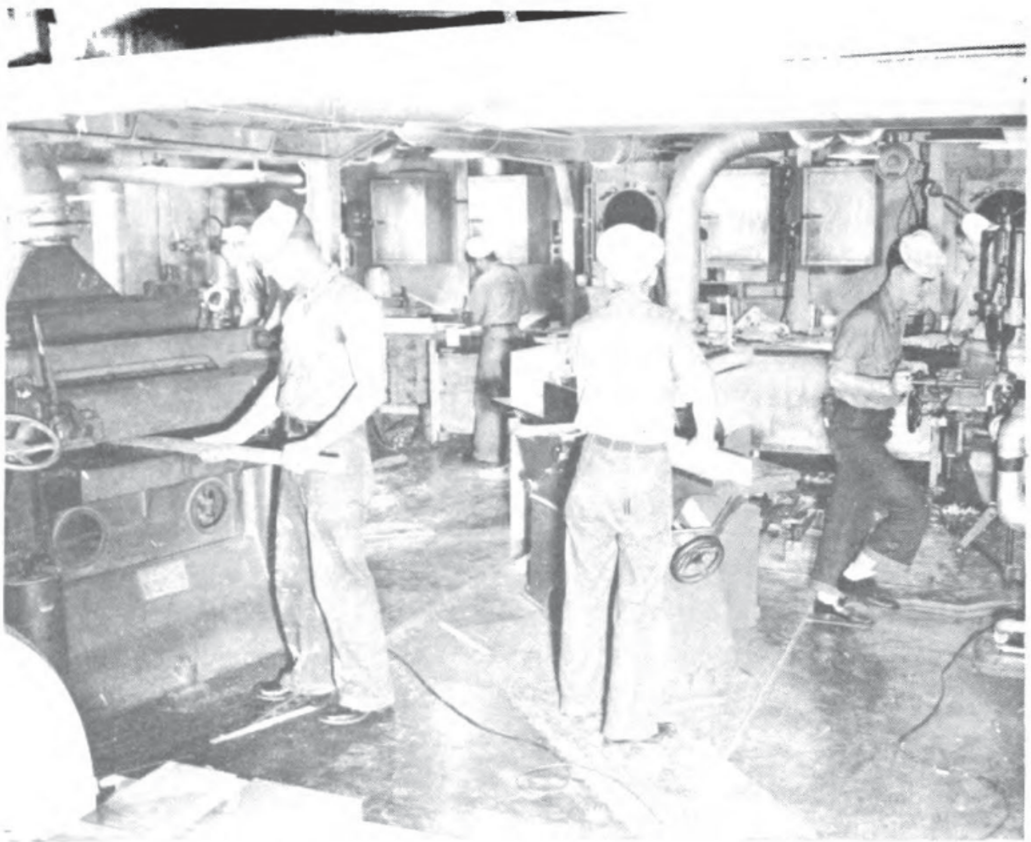


Figure 7–12.—Builders using woodworking machines.

of cut and then use a try square to check the angle of the fence with the infeed bed. Next, take a look at the grain of the wood you're going to cut to determine which end to push through first. It is always best to cut WITH the grain to prevent tearing of the wood fibers or splitting off of small chunks of wood.

When you've checked the grain and made necessary machine adjustments, switch on the power and place the edge to be squared on the infeed table with one face against the fence. Hold the board firmly against the bed and fence and push it slowly and steadily into the cutterhead. AVOID HAVING YOUR HANDS DIRECTLY OVER THE CUTTERHEAD AT ANY TIME, particularly when you're jointing short, narrow, or knotty boards. As soon as the board is about half-way across the cutterhead, use your left hand to reach around and steady the board against the outfeed bed. When the cut is almost finished, use both

hands over the outfeed bed. Push the board steadily and, when the cut is finished, push the board on through far enough to allow the guard to slide back over the cutterhead.

DON'T push the board through the jointer by using your thumb or fingers at the end of the board—keep your hands and fingers on top of the board at all times.

Use a surfacer for truing faces of boards if one is available. If you don't have one, you can use a jointer. When using the jointer to dress a face, keep your hands as far as possible from the cutterhead, particularly when you're dressing thin, knotty, or cross-grain boards. Hold a board down with your fingertips—you'll get a better grip than if you use the palms of your hands.

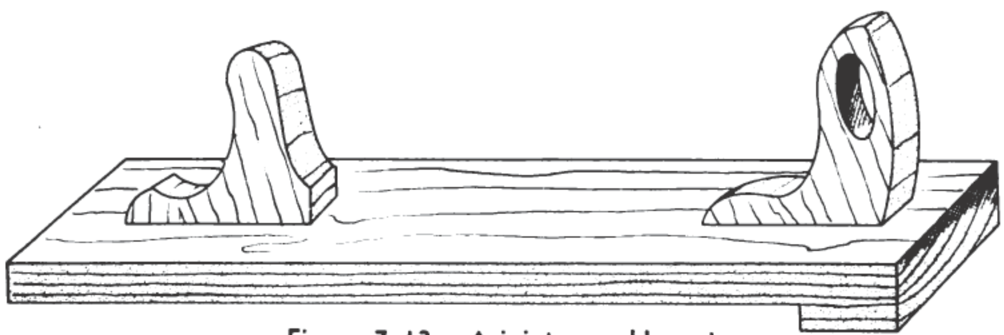


Figure 7–13.—A jointer pushboard.

Avoid jointing short pieces whenever possible by jointing a longer piece and cutting it to length. When you have to joint pieces shorter than 18 inches long, feed them with a PUSHBOARD. You can make a pushboard in the shop similar to the one shown in figure 7–13. It is usually inadvisable to joint pieces under 8 inches long, even if fed with a pushboard.

If you joint a board and notice that the cut is too deep for a short distance at either end, it is probably caused by misalinement of the beds with each other or with the cutterhead knives. However, the trouble may be caused by improper feed—unequal pressure as the board is pushed across the cutterhead.

Rabbeting can be done on the jointer by using the left edge of the beds. One dimension of a rabbet is obtained

by setting the depth adjustment, the other by adjusting the fence. Cut a rabbet with the board in a vertical position, if possible. It is necessary to remove the guard when rabbeting, so you'll have to be unusually careful. Be sure you replace the guard when you have completed the rabbeting job.

Jointer Safety Precautions

It's always better to take several light cuts rather than one heavy cut.

Don't use a machine that has dull knives. A dull machine will not cut properly and will have a tendency to kick the work out from under your hand. It won't produce a smooth cut, but will leave a burned or irregular surface. A dull machine will also overload the motor.

Keep your hands ON TOP OF THE BOARD and shift them as you push the board along, so that they are never directly over the cutterhead.

Keep the deck clear of blocks, chips, and sawdust. Keep the beds clear too, especially the infeed bed, or you won't get a true cut.

Avoid jointing boards which contain loose knots. The fast-moving cutterhead may kick them out and weaken the board so that it may break.

Keep your eyes and attention on your work ALL THE TIME. Shut off the motor as soon as you are through with the machine. Replace the guard immediately after completing a rabbeting job.

Don't tinker with the setting of the cutterhead knives unless you have had special instruction. But, when a more experienced petty officer is changing the knives or grinding them, notice how he does it, so you will get the idea of how it is done. Notice particularly how the knife edges are lined up so they will be exactly tangent with the outfeed bed.

THE SINGLE SURFACER

Surfacers are designed to plane the faces of boards or planks. Some surfacers will plane or dress two or four

surfaces with one pass of the board, but the type usually found in the Navy shop will surface only one face at a time and is known as a SINGLE SURFACER. The one shown in figure 7–14 will handle pieces up to 8 inches thick and 24 inches wide.

The two principal adjustments are located at the left side of the machine. The FEED-SPEED change lever is at the lower left, below the switch. The THICKNESS SETTING is controlled by the large crankwheel at the left of the

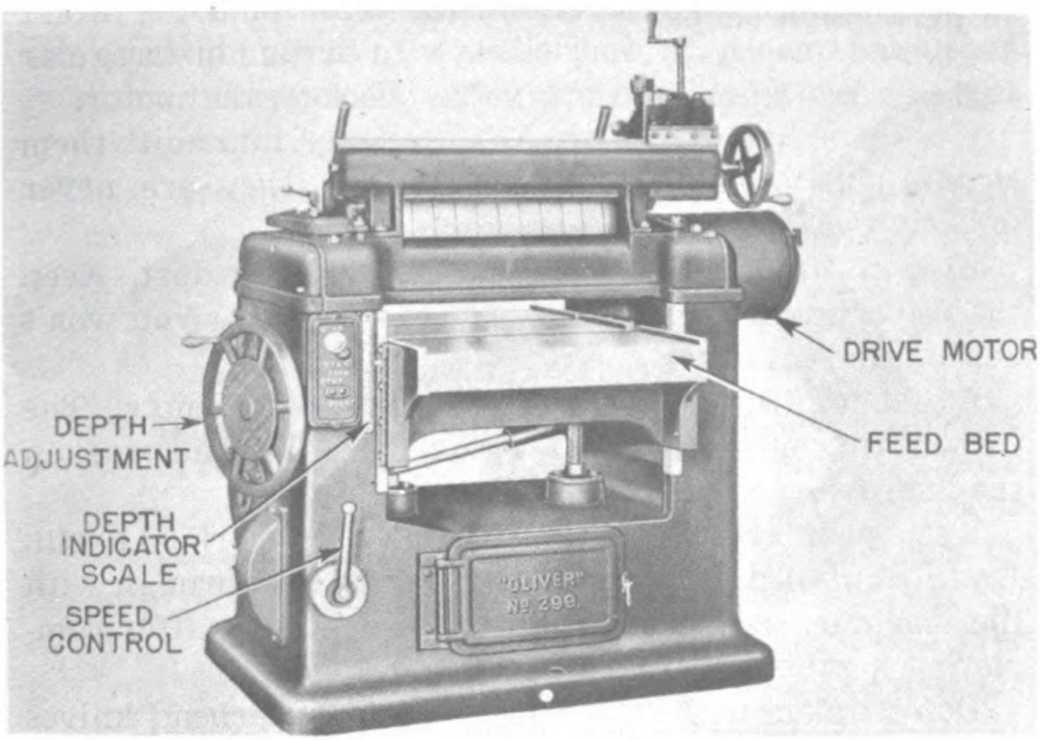


Figure 7–14.—A single surfacer.

switch and is indicated on the scale at the right of the switch. The mechanism at the upper right is a permanently located knife grinding and jointing attachment which can be used to recondition the knives without removing them from the cutterhead.

When you use this machine, avoid standing behind it—pieces are sometimes kicked back. Also, don't bend over

and peer into the rear of the machine if a board gets stuck—keep clear and cut the switch.

It is dangerous to run short pieces through the surfacer, so find out the minimum allowable length (usually about 11 inches) before you try to surface a short piece.

SANDING MACHINES

It takes a lot of slow work to sand wood smooth by hand, so you'll probably be provided with one or more sanding machines. These will probably be portable or semi-portable—not the heavy-duty sanding machines used in production shops.

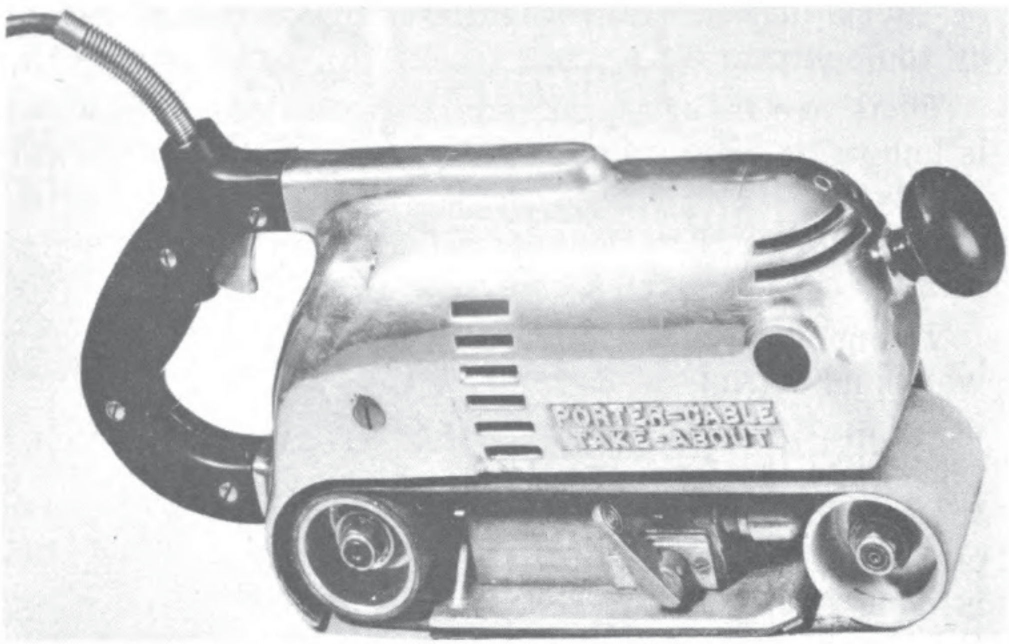


Figure 7–15.—Portable belt sander.

The portable belt sander (figure 7–15) is handy for almost any kind of sanding job. This sander can speed your work when you are sanding floors, interior wood trim, furniture, and similar work.

When you use a portable belt sander, don't press down on the machine or "ride it"—the weight of the machine exerts enough pressure for proper cutting.

You may have a small, bench-type belt sander which

is similar to the portable machine, except that its use is limited because the work must be brought to it. Such a machine may have a sanding disk attachment which is especially useful for rounding corners and sanding disks.

A portable disk sander, the type used by automobile finishers and body men, is handy for sanding irregular surfaces. It has a flexible backing disk to be used on uneven or irregular surfaces.

THE WOOD LATHE

The wood lathe is essentially a machine designed to spin or rotate pieces of wood so these pieces can be shaped by sharp cutting tools which are hand-held and directed by the operator.

There are many types of lathes. The one shown here is known as a MOTOR HEADSTOCK lathe, because the work is driven directly by the motor. Other lathes are driven by V-belts or flat belts from motors mounted above, behind, or below the lathe, or from line shafts.

Two general types of woodturning done are FACEPLATE work and SPINDLE work. The lathe shown in figure 7–16 is set up for faceplate work. In this method the work is secured to the faceplate with screws and is held only by the faceplate. The faceplate is threaded to screw over the end of the SPINDLE. Faceplate turning of large diameter is done from the left end of the lathe by mounting the stock outboard on the combination faceplate, handwheel, and brake wheel shown at the left of the motor. Extremely small pieces can be mounted inboard by means of the small SPUR shown in the illustration.

Spindle turning is done by supporting the length of wood between two CENTERS—a LIVE or SPUR CENTER at the driving end and a DEAD or CUP CENTER at the driven end. The live center has projections or spurs which are driven into the wood to prevent it from slipping as it is rotated. The dead center is mounted in the TAILSTOCK

and does not revolve. The HANDWHEEL shown at the right is used to adjust the dead center in the tailstock and the LEVER-TOP SCREW is used to lock the adjustment once it is made. The tailstock itself is held in the desired position by the locking arrangement shown in the illustration.

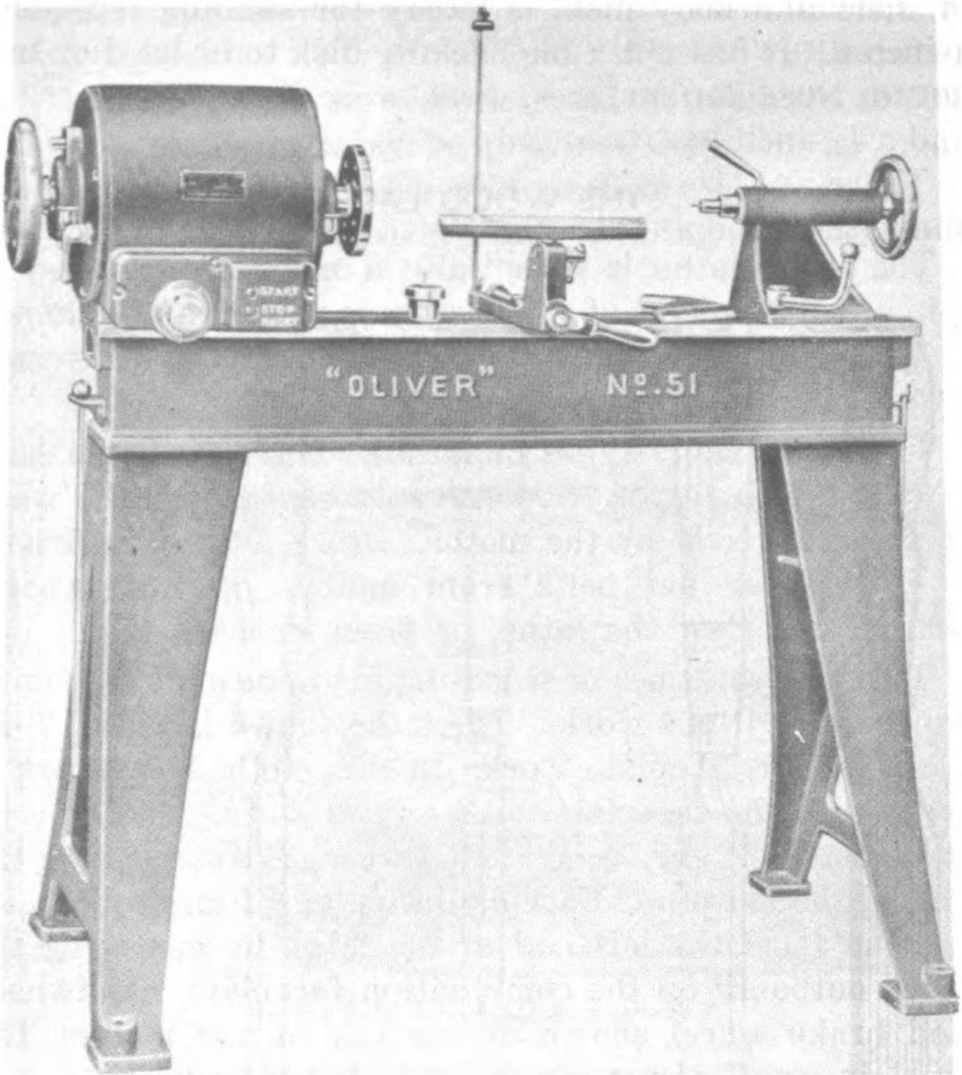


Figure 7-16.—A standard wood lathe.

Both headstock and tailstock are mounted on a rigid, machined BED. The TOOL-REST HOLDER is also mounted on this bed. This holder allows the TOOL REST to be adjusted horizontally and vertically, and is provided with two locks to maintain adjustment once it is made.

Start and stop switches and the SPEED CONTROL are conveniently located on the base of the motor headstock. The rod on the left end of the machine is used to knock out the live center.

The actual cutting work of the lathe is done with a set of special lathe turning tools which includes ½- and 1-inch SKEW CHISELS, ¼-, ½-, ¾-inch GOUGES, a ½-inch ROUND NOSE CHISEL, a ½-inch SPEAR or DIAMOND point, and a ⅛-inch PARTING TOOL. Refer to figure 7–17.

There are two general methods of using these tools to shape the wood as it revolves. The best method—and the

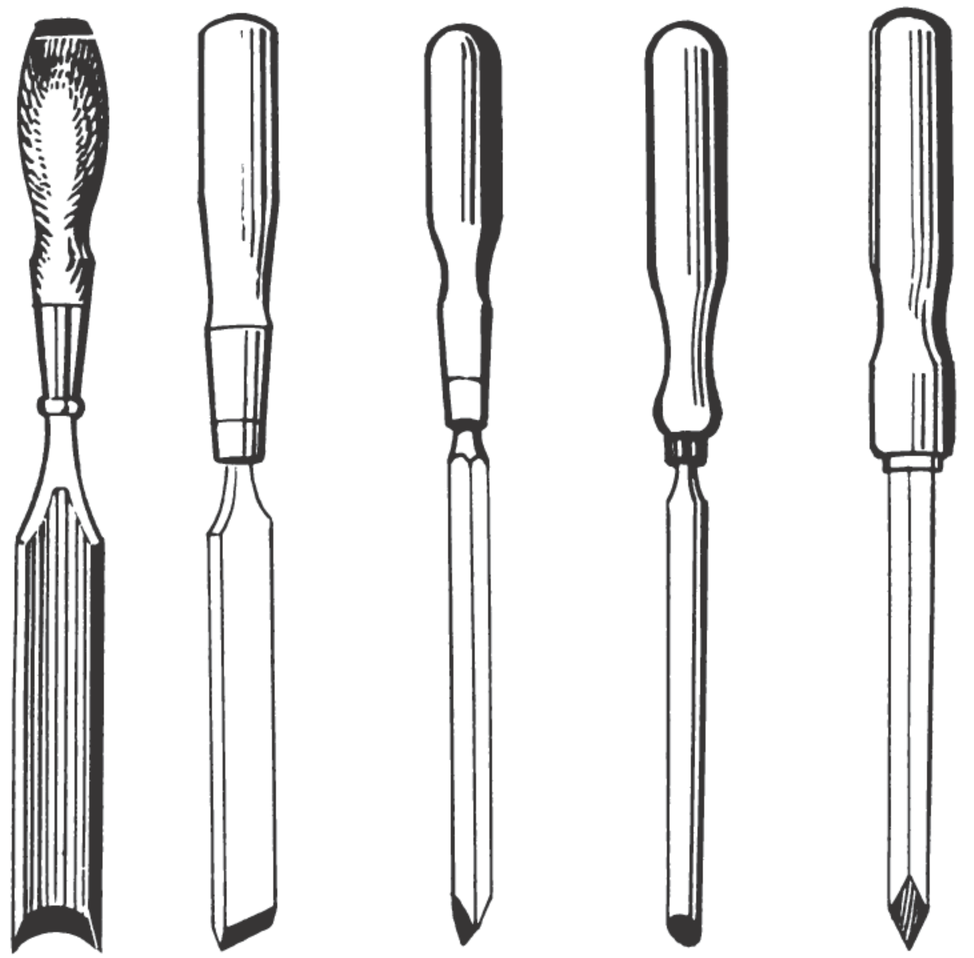


Figure 7–17.—Special lathe turning tools.

one that requires the most skill—requires that the tools be held in such a manner that the wood will be removed by PARING or SHAVING. You will probably start out by using the other method—SCRAPING—which is much easier and safer for the beginner but which never produces the fine, smooth finish you can obtain by the cutting method.

You can't expect to learn to use a lathe by reading a book, because its use depends almost entirely on the skill of your hands. So, get a skilled woodturner to start you off and guide your efforts until you have mastered the basic uses of all the tools on both faceplate and spindle work. When you gain confidence and more skill, you can go on to a little fancy work.

Lathe Safety

You'll have to be especially careful when you use the lathe. The fast turning stock can be plenty dangerous if you get your shirtsleeve tangled up in it, so keep your sleeves buttoned or rolled above your elbows. Wear goggles when you are doing rough turning to protect your eyes from chips and dust.

Before you start turning the lathe, be sure you have the stock mounted securely on the faceplate or between the centers. If it isn't properly mounted, the stock may fly out. Use your turning tools carefully or they may catch in the wood and be jerked out of your grasp. Fortunately for you, a thrown tool usually goes the other way—toward the back of the lathe. That's a good reason why no one should stand behind a lathe.

Don't use excessive speeds for turning. If you do, the stock may be thrown clear of the lathe. Always use the slowest speed that will enable you to do a good turning job. Avoid slowing the machine suddenly when you're doing faceplate work—the momentum of the stock may unscrew it from the spindle and throw both the faceplate and the stock.

The lathe won't be dangerous if you use it correctly and carefully. But it's one machine that can't be adequately

guarded, so you have to be on your toes all the time. After you really learn to use it, you'll get more pleasure out of it than any other machine in the shop.

DRILL PRESS

A standard small drill press is illustrated and described in your *Basic Hand Tool Skills* manual. It may be used for both woodworking and metal working. The bits used with the drill press resemble auger bits, but they have screwless spurs.

For safety in using the drill press, make sure the stock is firmly secured before you start the drill motor. Always keep belt and pulley guards in place.

MORTISER

The mortiser, which actually cuts a square hole in wood, is used primarily to cut the mortises for the various types of mortise and tenon joints. It works by means of a hollow chisel in which a special spurless auger bit revolves at high speed. The cutting mechanism is actuated by a foot lever, and depth adjustment is made by lowering or raising the working table. A screw-type clamp holds the stock securely in place. Stops are provided on a rod to control the length of mortises.

Care must be exercised in setting the bit and chisel so that neither will be overheated by the friction developed as a result of the high speed of the bit.

TENON MACHINE

You probably won't have a machine for cutting tenons, because tenons can be satisfactorily cut on the circular saw with the dado head. A simple tenon machine has two individually driven cutter heads. The space between the cutterheads is adjusted to the desired thickness of the tenon. Some machines are equipped with cut-off saws to cut the tenons to the desired lengths.

The tenon cutting machine is extremely dangerous because of its many sharp revolving parts. It should not be used without all the available safety guards. Even then the machine is dangerous, because all parts cannot be adequately guarded.

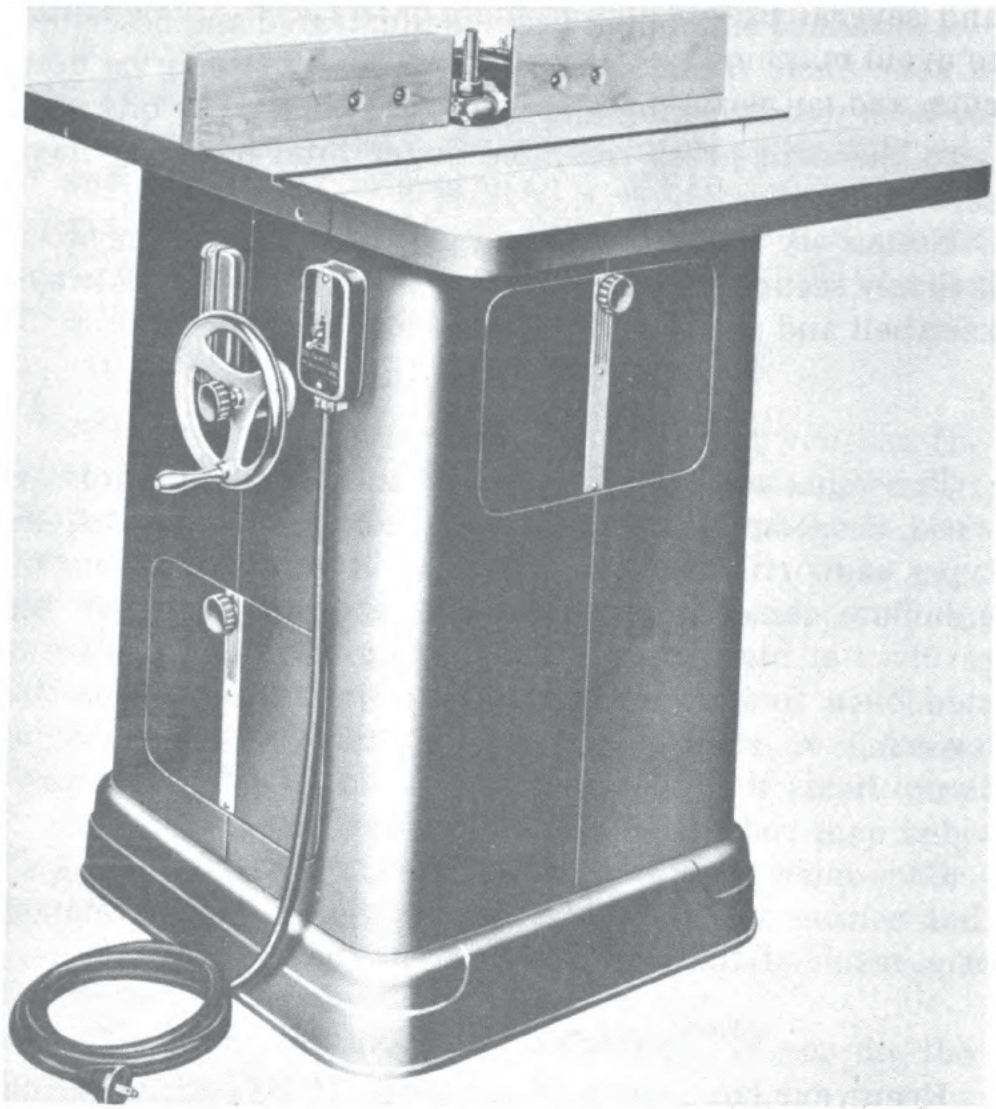


Figure 7–18.—A light-duty wood shaper.

SHAPER

All kinds of fancy edge cuts can be made on a high-speed spindle shaper. The spindle of a shaper usually revolves at 8,000 to 12,000 rpm. The actual cutting is

done either with solid three-blade cutters or with cutter heads which have two or three removable and adjustable cutters.

The shaper is adjusted by raising or lowering the spindle. Some cuts will require the use of several cutters and several passes of the stock. Here again, it's better to avoid making heavy, one-pass cuts—make several light cuts, and cut with the grain when you can.

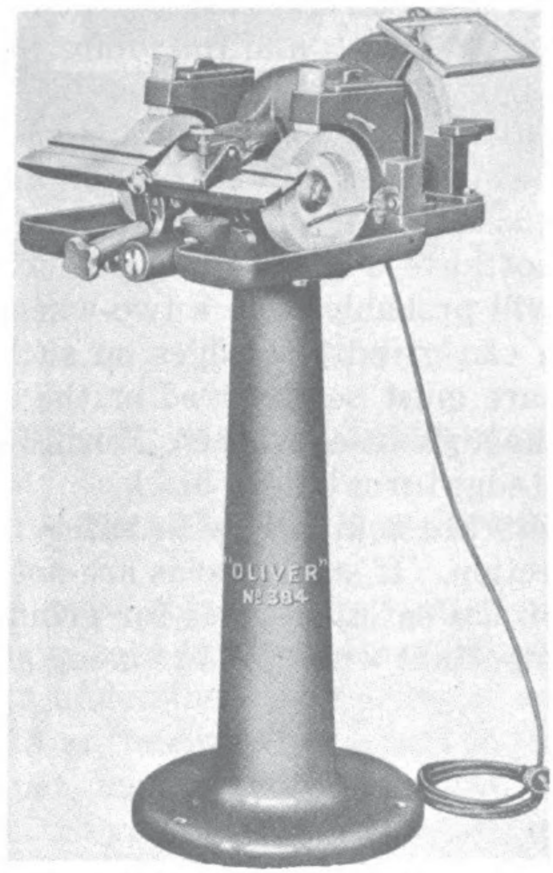


Figure 7–19.—A standard tool grinder.

Keep your hands as far away from these cutters as you can, because the stock may "grab" and pull your hands into the cutters. Use any available guards—this machine is plenty dangerous, so use it carefully.

TOOL GRINDER

A builder is often judged by the condition of his tools, particularly those hand tools used for cutting and shaping

wood. Usually these tools are sharpened by honing, if they are only dull, and by grinding if they have nicks or are otherwise in bad condition. The reconditioning of plane irons and chisels is explained and illustrated in your *Basic Hand Tool Skills* manual.

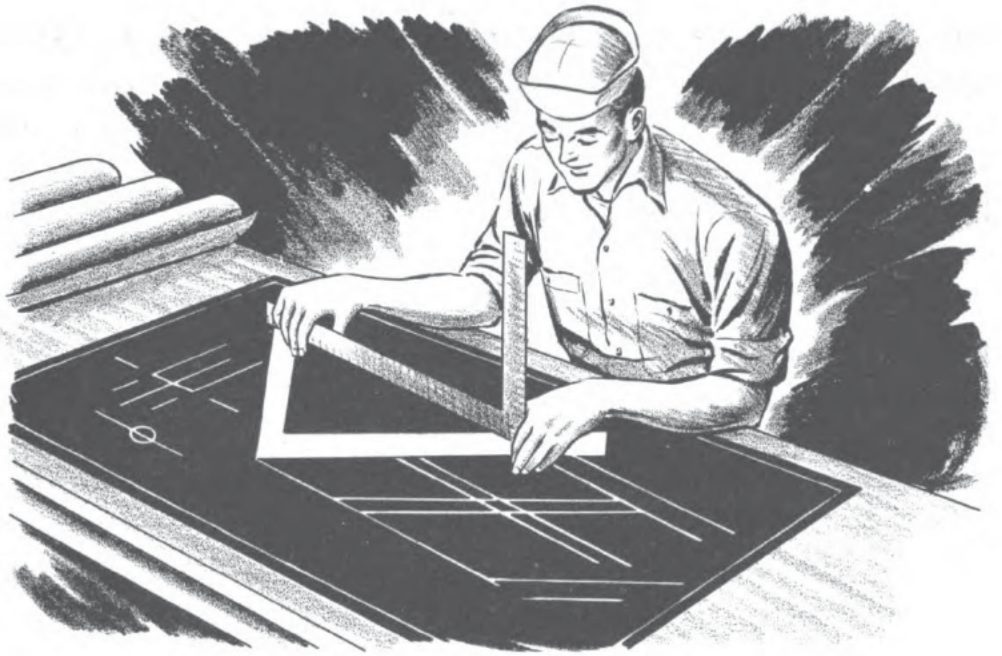
Grinding of such tools can be done on a grinder like the one shown in figure 7–19. This machine has two, slow-turning, porous oilstone wheels, which are saturated with kerosene or a special oil. A special holder is provided for plane irons and chisels and for jointer knives if they are not over eight inches long. The third wheel of this grinder is a standard aluminum oxide abrasive wheel which is provided for rough and general duty grinding. This wheel is usually operated at motor speed.

If you do not have a special tool grinder (with slow wheels) you will probably have a two-wheel, bench-type grinder. You can grind tool edges on such a machine, but extreme care must be observed or the edges will be "burned" by the high speed wheels. Burning is indicated when a ground edge turns blue or black.

Most grinders are equipped with safety glass guards for your protection. If such guards are not provided, or are inadequate, use safety goggles for grinding. This is particularly important when you are using a fast-turning dry wheel.

QUIZ

1. The plain dado joint is often used in making cabinets and shelves. How is it usually cut?
2. What is a spline?
3. Of what does the mortise-and-tenon joint consist?
4. For what kind of work is the skill saw used?
5. How is the size of a band saw designated?
6. What is the reciprocating principle on which the jig saw works?
7. What is the most common use of the jointer?
8. You can grind tool edges on a two-wheel, bench-type grinder. Why must extreme care be observed?



CHAPTER 8

BLUEPRINTS AND THE STEEL SQUARE

LANGUAGE OF THE BLUEPRINT

One of the most thrilling and satisfying pursuits of man has always been the "building" of something. It is not difficult to understand the feeling of accomplishment experienced by anyone who has a part in the construction of a skyscraper, naval base, or hospital. This lesson in blueprints brings you very close to that dream of accomplishment. No building can be constructed without plans and blueprints to guide the builder. The fundamental principles of architectural blueprints are the same as those in the engineering field which were discussed in your basic blueprints manual. It is only necessary to acquaint you with the type of symbols and the methods of presentation used by the architect in CONSTRUCTION blueprints.

To tell you everything you'd need to know to build the smallest type of structure would require many books.

The architect, in his office, makes the required working drawings for erecting a structure—from excavation to completion. The specifications which explain how the work should be done and the quality of the material to be used, together with the working drawings and details, give you clear-cut instructions needed to do the work. You must know and understand the language of blueprints so that you'll understand the instructions and dimensions given on a working drawing. Study your *Blueprint Reading*, NavPers 10077, until you know blueprint language thoroughly.

You'll find all the directions pertaining to "doing the job" in the working drawings and specifications. Also, you must refer to the detailed drawings called for on the plans. Plans, specifications, and details are all wrapped up in one package and you'll have to have all three to be able to use any one successfully. You should read all reference notes on a drawing. Overlooking one reference note may cause you a lot of headaches if you have to tear down parts of the structure and build them all over again. Follow all instructions on a blueprint in order to coordinate your work with that of your shipmates, and then the structure will be successfully and properly erected according to plan. If the foundation is not built according to the plan, the framework that is built on it won't fit, and so on throughout the building operation.

The architect, in order to save time and space, makes use of standard devices such as lines, symbols, and abbreviations. To be able to read blueprints, you must learn the meaning of all these devices.

LINES

The principal kinds of LINES you, as a builder, should be able to read and understand on a blueprint are illustrated in figure 8–1. Some of these lines have been discussed in your basic book, *Blueprint Reading*. Learn to distinguish each line by its weight or width.

Just as your daily newspaper denotes important news by headlines, your architect denotes important wall outlines by various weights of lines.

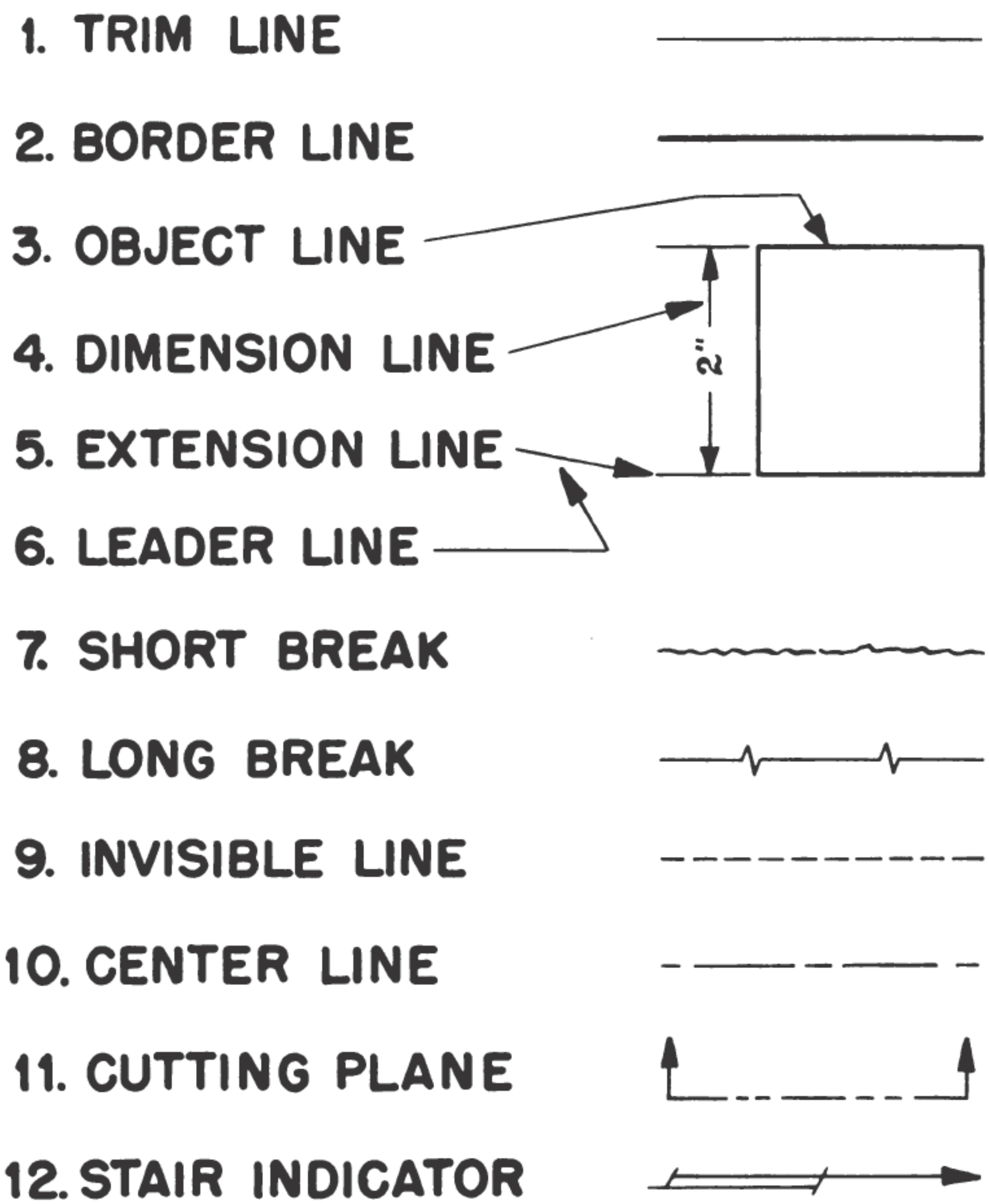
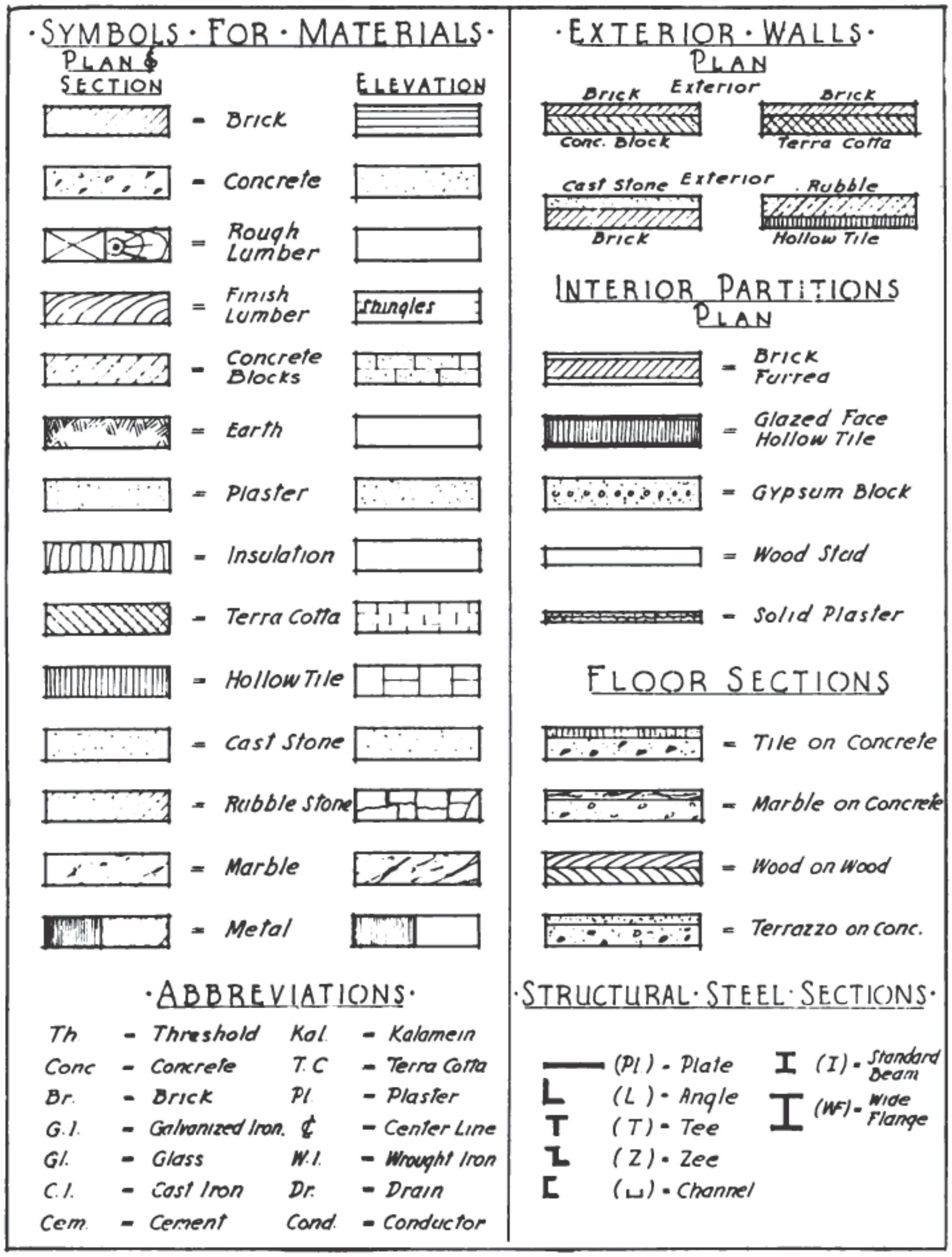


Figure 8–1.—Line indications.

SYMBOLS

By special ways of cross-hatching the sections, the architect indicates the materials of which the various

parts are constructed. You should learn the symbols most commonly used for building materials, such as those for concrete, brick, wood, and plaster. On working drawings,

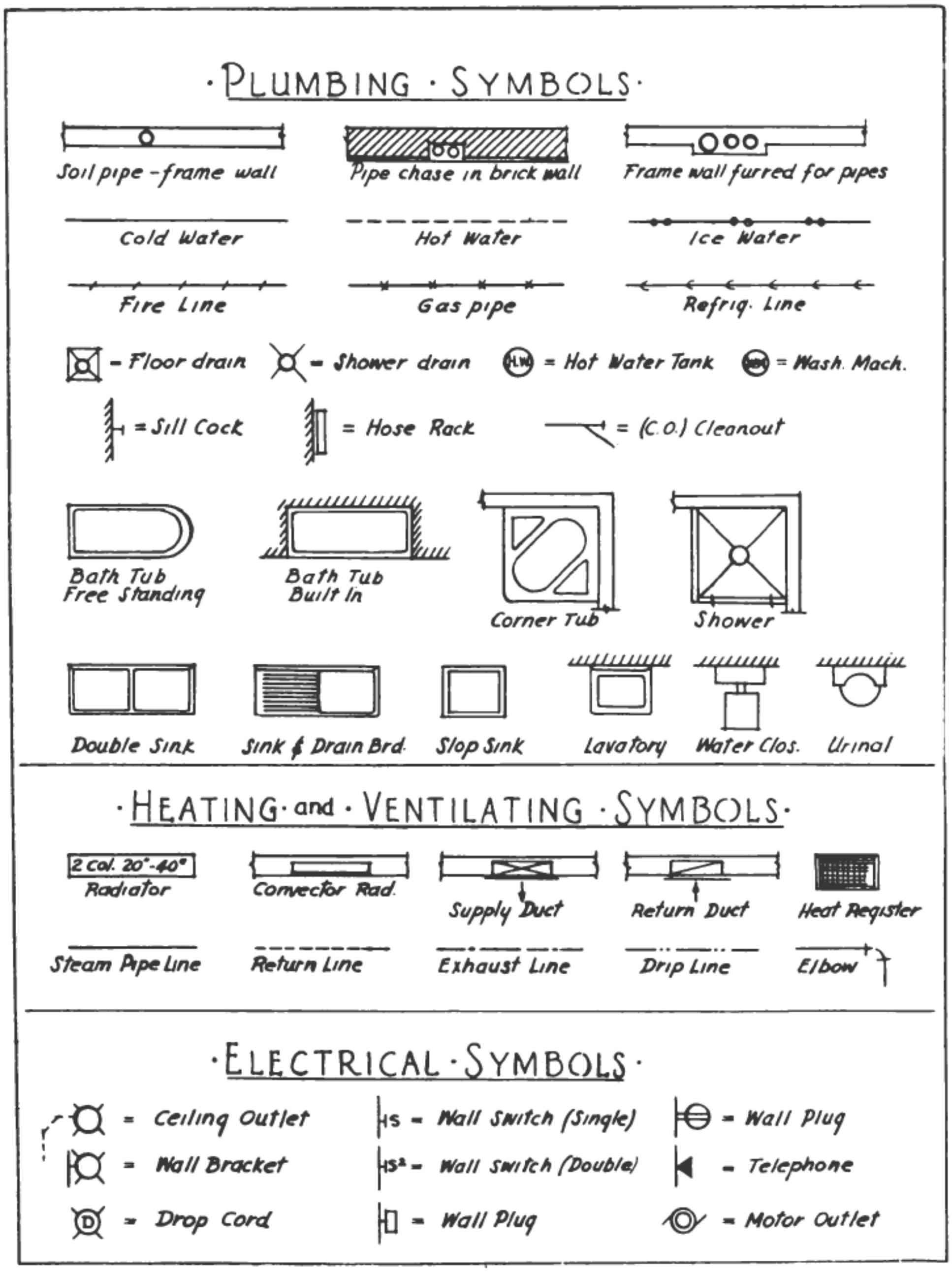


Courtesy of McGraw-Hill Book Co., Inc.

Figure 8–2.—Architectural symbols.

where other materials are used, always refer to the key or list of standard symbols. The principal symbols used in building jobs are indicated in figure 8–2. It is necessary, when erecting structures, for you to leave the

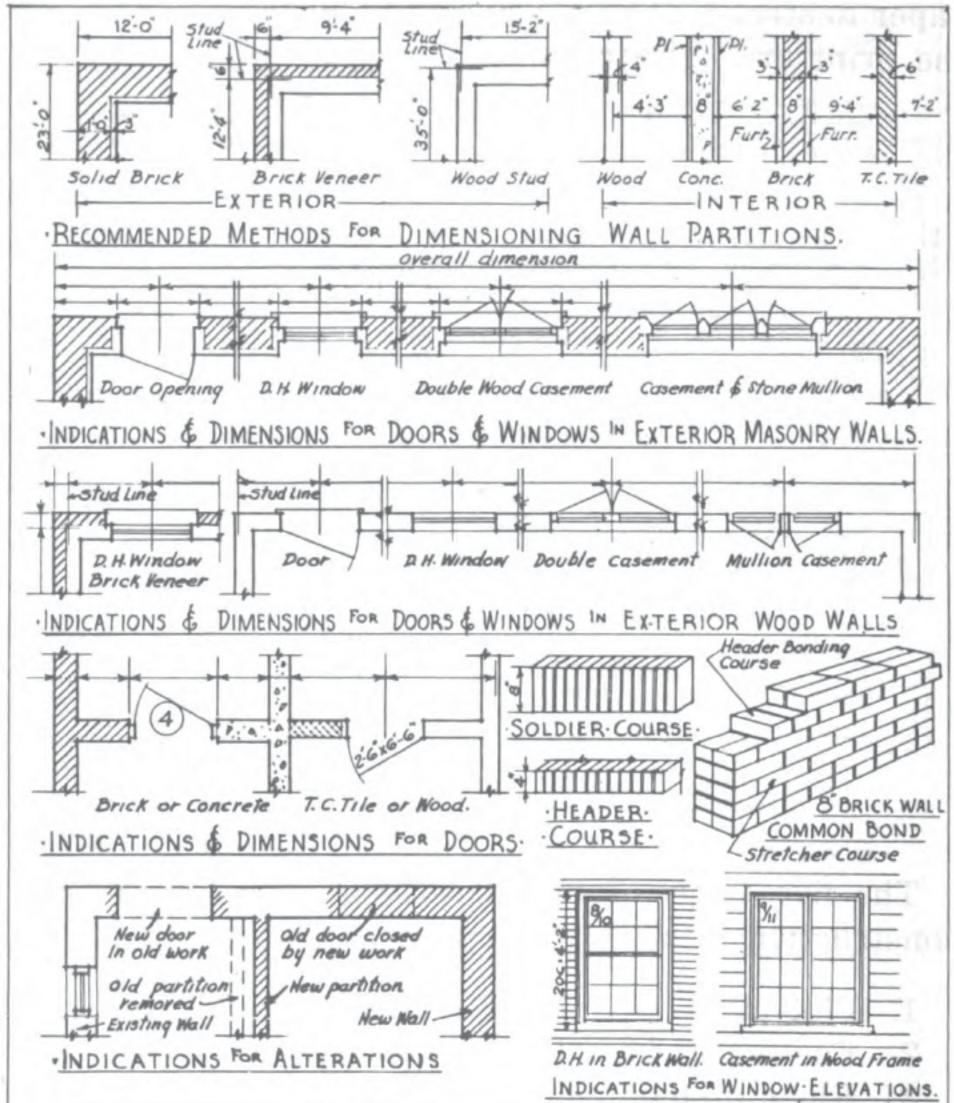
proper spaces for plumbing and electrical equipment; therefore, you should be familiar with the plumbing and electrical symbols illustrated in figure 8–3. The conventional symbols to indicate dimensions for wall partitions, doors, windows, and exterior walls are illustrated in figure 8–4.



Courtesy of McGraw-Hill Book Co., Inc.

Figure 8–3.—Symbols for fixtures.

You can see readily that it is impossible for the architect to draw buildings of actual size on paper. Therefore, in order to help you to see how the structure should look, he reduces all dimensions to SCALE. On blueprints, he may represent a foot by one inch, so that a sidewall of 20



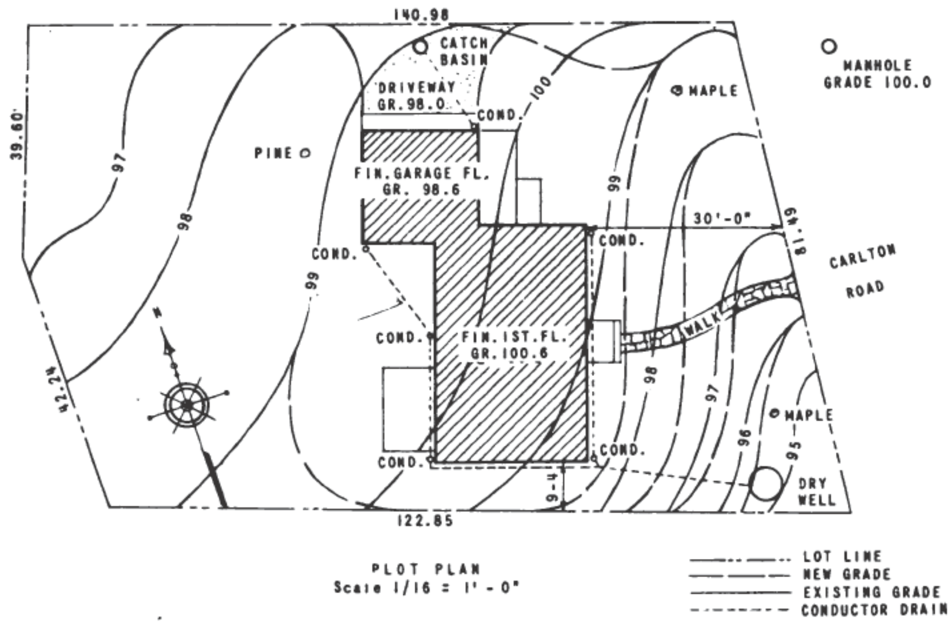
FINISH SCHEDULE

NUMBER	ROOM	WALLS	CEILING	DADO	BASE	FLOOR	CORNICE	NOTES
101	Liv. Room	Plaster	Plaster	Wood	Wood	Oak	Wood	Bookcase
102	Lavatory	"	"	Tile	Tile	Tile	——	——
103	Hall	"	"	——	Wood	Oak	Pict. Mold.	See detail
104	Kitchen	"	"	——	Rubber	Linoleum	——	——

Courtesy of McGraw-Hill Book Co., Inc.

Figure 8-4.—Conventions.

feet would be drawn 20 inches long. The scale is always indicated on the working drawing. Generally, you'll find the scale indication on the bottom right-hand side of each drawing. Dimensions of a building should not be scaled or measured from a blueprint. Always use the dimensions as indicated. You can't scale dimensions from a blueprint because the process or printing usually causes the paper to stretch or shrink, and measurements taken from the print are not accurate.



Courtesy of McGraw-Hill Book Co., Inc.

Figure 8-5.—Plot plan.

The five types of blueprints which you'll use in the construction of simple and small structures are:

1. Plot plan.
2. Footing and foundation plans.
3. Floor plans.
4. Section plans.
5. Elevations.

For larger construction jobs, scale details, full-sized details, mechanical drawings, and shop drawings play a very important part in representing the buildings.

Plot Plans

Plot plans give you an accurate picture of the plot or area of ground on which the structure is to be constructed. Information such as slopes, existing trees and their sizes, locations and depths of available water and sewer mains, and other pertinent ground details are shown. The surveyor gives all this necessary information to the architect on a plot plan similar to the one illustrated in figure 8–5. You'll notice numbers with notations as Fin 1st Fl. Gr. 100.6. On the same plot plan, in the upper right-hand corner, you'll observe 0 Manhole Grade 100.0. This is the fixed point or grade determined by the surveyor and is called a bench mark. From this bench mark, the surveyor determines elevation of other points of the area in relation to this fixed point. Therefore, Fin 1st Fl. Gr. 100.6 indicates that the first floor will be finished six tenths foot higher than the manhole. Elevations are usually given in tenths of a foot instead of in inches. Driveway on the Gr. 98.0 (see figure 8–5) indicates that the grade of the driveway will be two feet below the manhole grade 100.0.

The plot plan shows the grade of the first floor of the building in relation to the ground around it, the number of steps required at entrance doors, the necessary walks and driveways, the dimensions of the lot, and the location of the building on it. The points of the compass are also indicated on the plot plan.

Floor Plans

A horizontal section through the building to indicate the arrangement for one floor is termed the "floor plan." On floor plans, the architect indicates the arrangement of sidewalks, windows, doors, fireplaces, closets, and plumbing and electrical equipment. He also indicates the materials that are to be used. You should read all reference notes and symbol keys, and study all drawings referred to by the architect on the floor plan. Now, it is

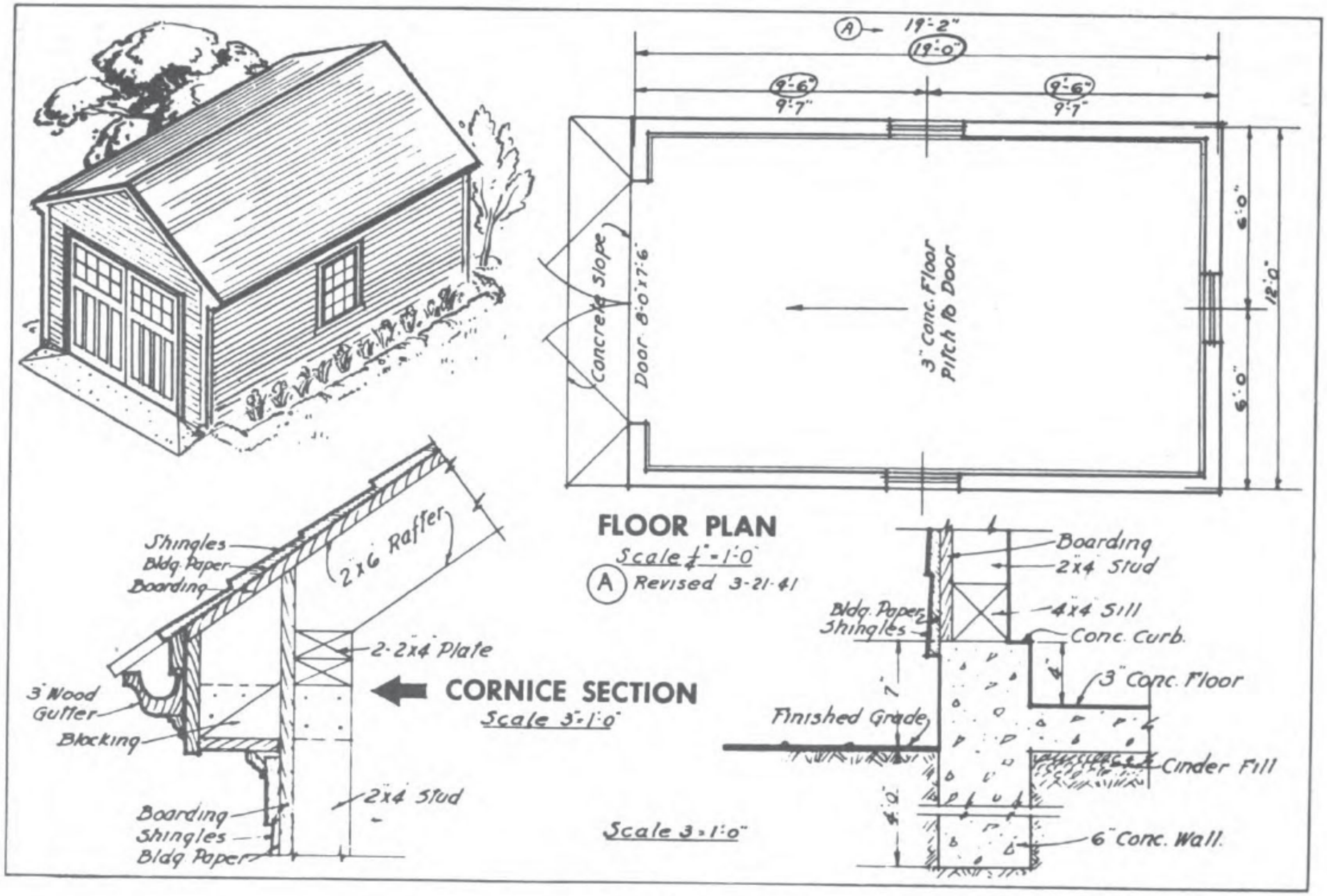
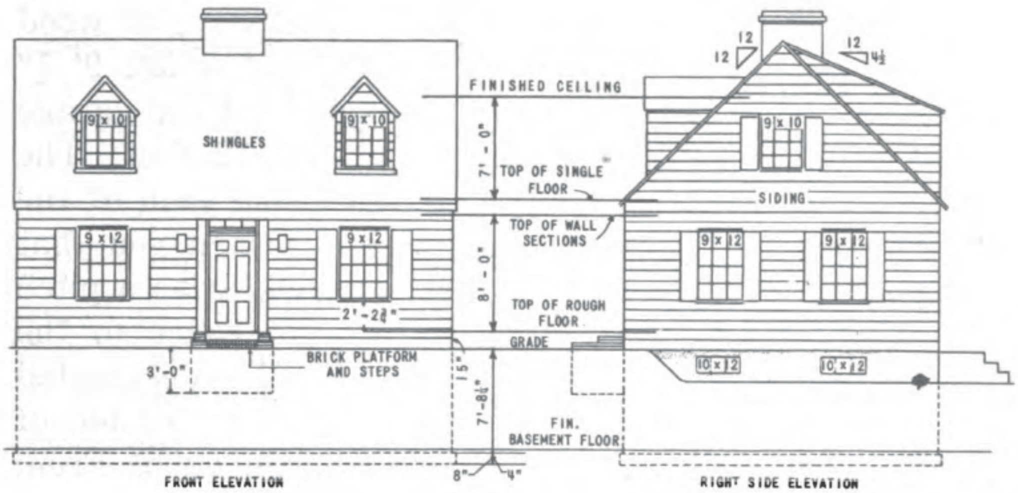


Figure 8–6.—Wooden garage. *Courtesy of McGraw-Hill Book Co., Inc.*

recommended that you observe figure 8–6 very carefully. This figure shows the floor plan of a wooden garage. The sketch shows you how the garage will look after it is completed. The architect has drawn the floor plan to the scale ¼″ = 1′ - 0″, as indicated. The overall length of the garage is denoted by the figure on top of the dimension line as 19′ - 2″. Just below this dimension you'll observe the circled figure 19′ - 0″. A circled dimension indicates that a revision has been made. In this case, the length of the garage has been changed to 19′ - 2″. From the conventional symbols, you immediately see that there are three windows and that the walls are of wood construction. The center of the side windows are 9′ 7″ from the front of the building. The width of the garage is noted by the dimension line as being 12 feet. The centered rear garage window is 6 feet from each of the garage sidewalls. The architect has informed you that the floor will be of concrete, 3 inches thick, with a pitch toward the front of the garage. The entrance to the garage has been noted to be 8 by 7½ feet. The designated area of the front floor entrance is to be constructed of concrete, on a slope from the entrance to the curb. From your symbols, you know that a door is indicated by a single line, and an arc of a circle shows the direction in which it opens. Therefore, from the illustrated plan, you know that there are two doors which swing out at the entrance to the garage. The sill section has been drawn to the scale of 3″ = 1′ - 0″. In this section, the architect has shown you that the concrete foundation walls are to be constructed 6 inches thick and 7 inches in height. The foundation extends 4 feet below the finished grade. The sidewalls are to be constructed of boarding made fast to 2″ x 4″ studs attached to 4″ x 4″ sills. He also directs you to attach building paper and shingles to the four exterior sides of the sidewalls. The architect informs you that, in the cornice section, the roof rafters should be 2″ x 6″, made fast to two 2″ x 4″ plates.

Section Plans

All of the necessary structural arrangements for the interior of buildings cannot be shown by elevations and floor plans. Therefore, the architect cuts the building into vertical sections to indicate interior construction, design, and materials. The sill and cornice section, illustrated in figure 8–6 from which you were informed of the structural arrangement of the foundation walls, sidewalls, and roof of the garage, are typical examples of this type of blueprint.



Courtesy of A. Neil Sawyers Co.

Figure 8–7.—Elevation views.

Elevation Plans

An ELEVATION in architectural drawing corresponds to a front or side view in a machine drawing. It gives you a picture of the exterior sides of a building. Frequently the architect terms these elevations the north, south, east, and west elevations. Therefore, if the front of the structure faces north, this exterior view is the north elevation, and the other views are properly marked south, east, and west. Study the elevation shown in figure 8–7. Observe that the vertical distances between the floors are dimensions on the elevation. Therefore, the interior sidewalls

of the first floor would be 8 feet high, while the second-floor sidewalls would be 7 feet from the floor to the finished ceiling. Now, look at the windows. Some are marked 9 x 12, some 9 x 10, and others 10 x 12. These figures are dimensions, in inches, of the window glass used. If a number of panes of the same size are used in the windows, it is assumed that these figures apply to all of them. The architect indicates that the roof is to be a shingled roof. You'll observe on the elevation drawing that there is a portion of the building that is below the grade line. It is indicated by dotted lines, which with a dimension line indicate that the finished basement floor is 7′ 8¼″ below grade. The right triangles above the roof denote the pitch. Therefore, the pitch of the gable is 12 and 12, which indicates the vertical rise of the roof to each 12 inches of horizontal run.

REFERENCE NOTES

Architectural blueprints are easier to read in many ways than engineering drawings because there is always a subtitle with each view or plan, explaining what it is. But, on a shop drawing you must assume what the views are from experience. The architect indicates various materials not only by symbols, but also conveys this information to you by numerous notations.

SPECIFICATIONS

Specifications describe in writing "how the building is to be erected." They cover all of the important features of the job, some of which may not be indicated on the drawings.

Specifications denote:

1. The quality and quantity of material.
2. The methods of construction.
3. Standards of workmanship.
4. The manner of doing the work.

The blueprints and the specifications are inseparable; the blueprints indicate what the specifications cannot,

and the specifications indicate what the blueprints are unable to portray.

STEEL SQUARE

As a builder, you'll find the steel square one of your most valuable instruments. Experience and a knowledge of the rules for using the steel square will enable you to master its use. The square is a simple device for avoiding a lot of complicated mathematics. By the use of simple arithmetic and the steel square, you'll be able to handle any kind of building framing.

Make it a practice to use the square on all angle cuts. The more you use it, the more you'll learn about it. It isn't necessary for you to have the square mastered before you use it, you'll get the "feel of it" by practice. You'll find out that the more complicated cuts and angles can be made up by using your square to form two or more of the simple angles.

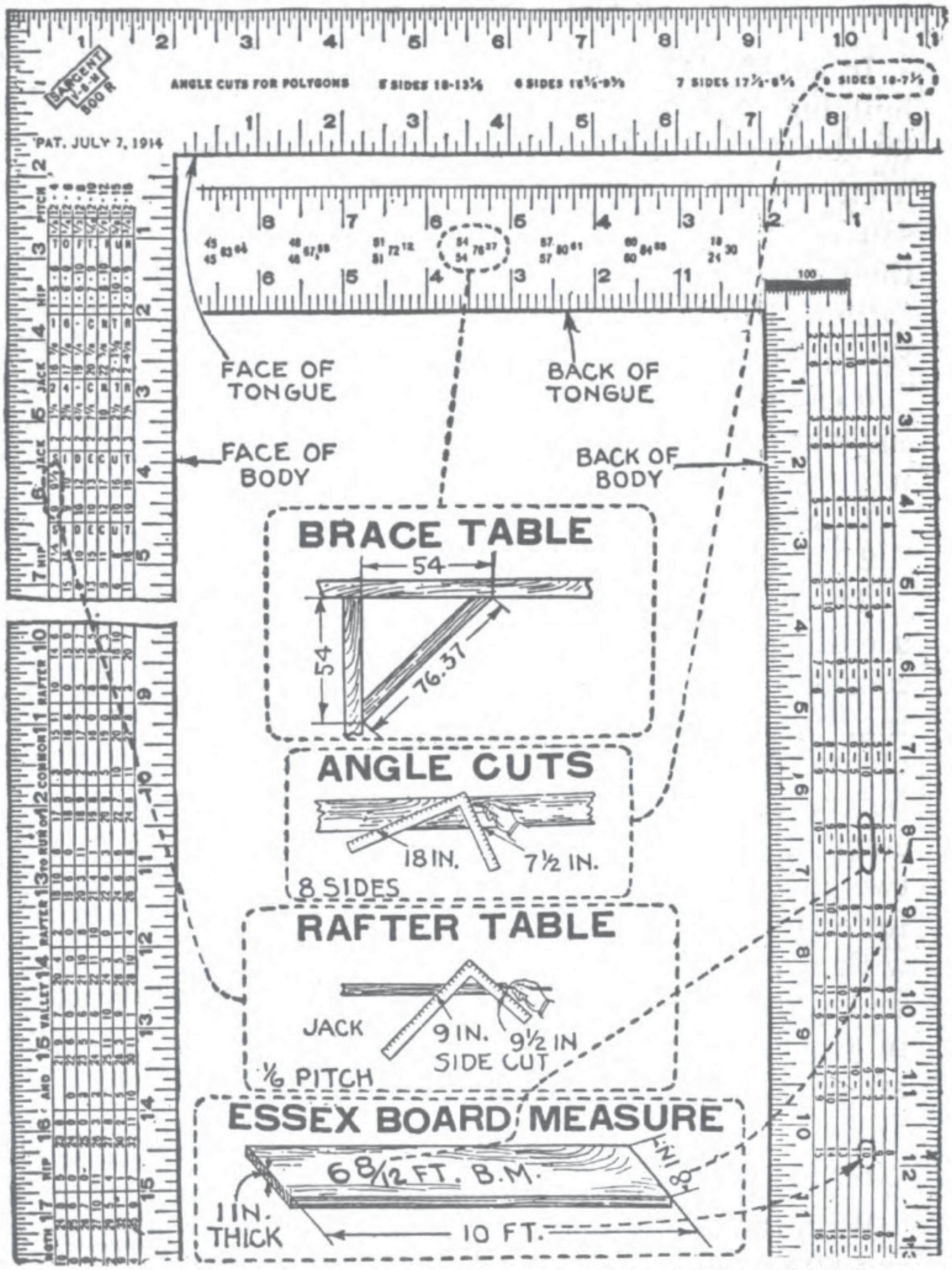
Don't be content to let someone else do all of the layout with the steel square. You, too, are anxious to rate that eagle on your arm. You must know the fundamentals of the square and know how to apply them to a roof, a stairway, or any other piece of material that must be cut on an angle. The first and most important thing is to be sure you are accurate in your figures. Don't be in a hurry to make the mark. Hold the square carefully in position, and be sure to check each end before marking. Make sure the scale number is on the true edge of the material, as some of the material may have the corner chipped. Get into the habit of being accurate and you'll have the steel square half mastered.

PARTS OF THE STEEL SQUARE

The so-called "steel" square is properly called a "framing" square—when a framing table and various other scales used in building framing are stamped on the square. Its parts are the tongue, blade, and heel. The longer and wider arm is the blade, the shorter and narrower arm is

the tongue, and the point where the two arms meet is called the heel.

The standard steel square has a blade 24 inches long and 2 inches wide, and a tongue from 14 to 18 inches long and 1½ inches wide. The blade or body is at right



Courtesy of Theo. Audel & Co.

Figure 8–8.—The front and back views of a steel square.

angles to the tongue. The face of the square is always stamped with the manufacturer's name and catalog number. Figure 8–8 illustrates the front and back views of a steel square.

USING THE STEEL SQUARE

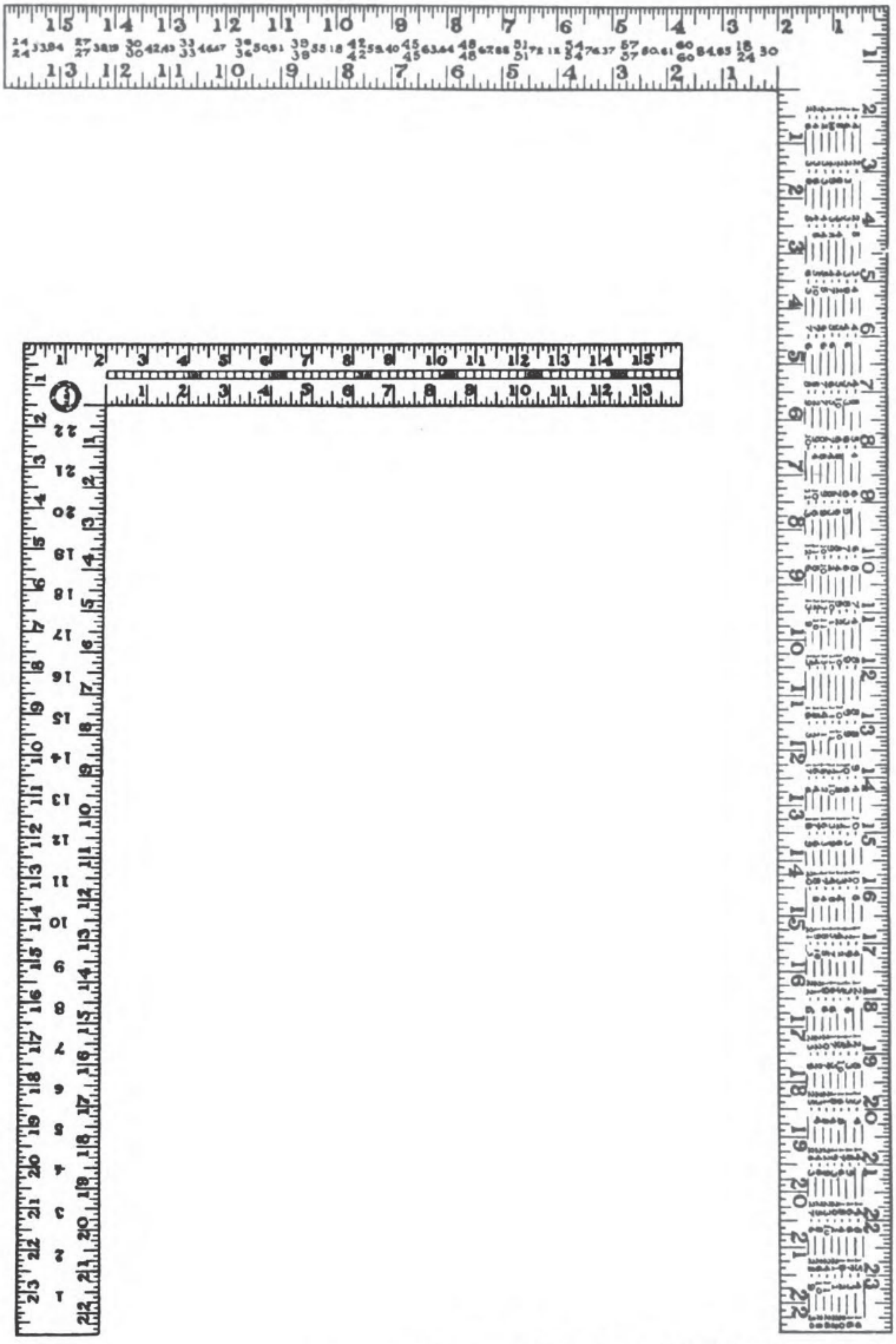
In construction work, such as roof-framing and stair-building layout problems, the steel square will be of invaluable assistance to you in making accurate measurements and determining angles. The markings on squares of different makes sometimes will vary both in their position on the square and in the manner of application. However, if you have a clear understanding of the application of the markings on any first-class square, you can easily become an expert in the use of any other square. The markings on a steel square may be divided into two groups:

1. Scales.
2. Tables.

The use of the scales will be discussed first, while the use of the tables will only be introduced. A detailed discussion of the tables will be found in chapter 13, "Framing," as you must understand the general arrangements of roof framework and the names of the different rafters before learning to use these tables. The various scales start at the intersection of the two outer edges, or the two inner edges, which is the heel of the steel square. Refer to figure 8–9 which shows a standard steel square with a 24-inch body. As the markings consist only of scales, this is not a framing square. You'll use this square in general carpentry, except in framing where the tables are required.

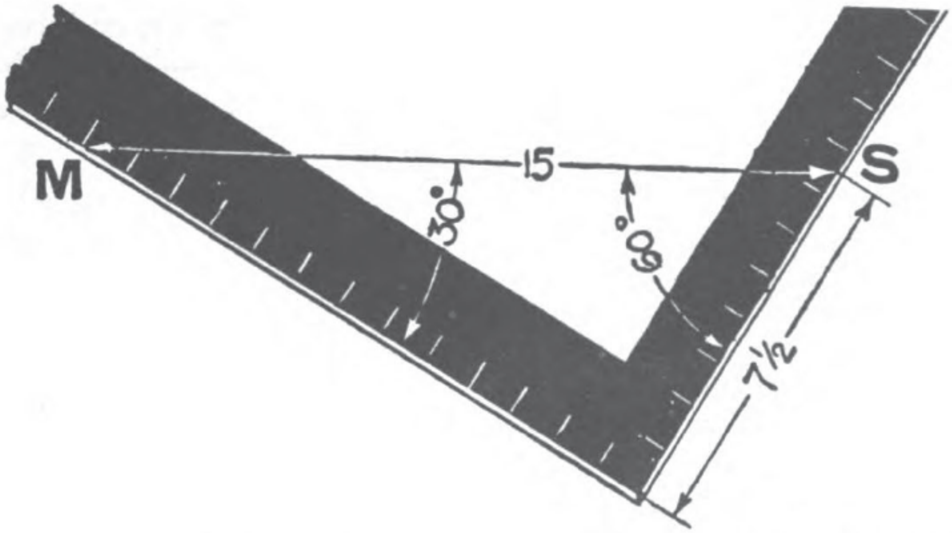
Laying Off Angles

With the use of the scales, you can lay off angles of 30 and 60 degrees. Mark off line *MS,* 15 inches long. Then place the square so that the body touches point *M* and so



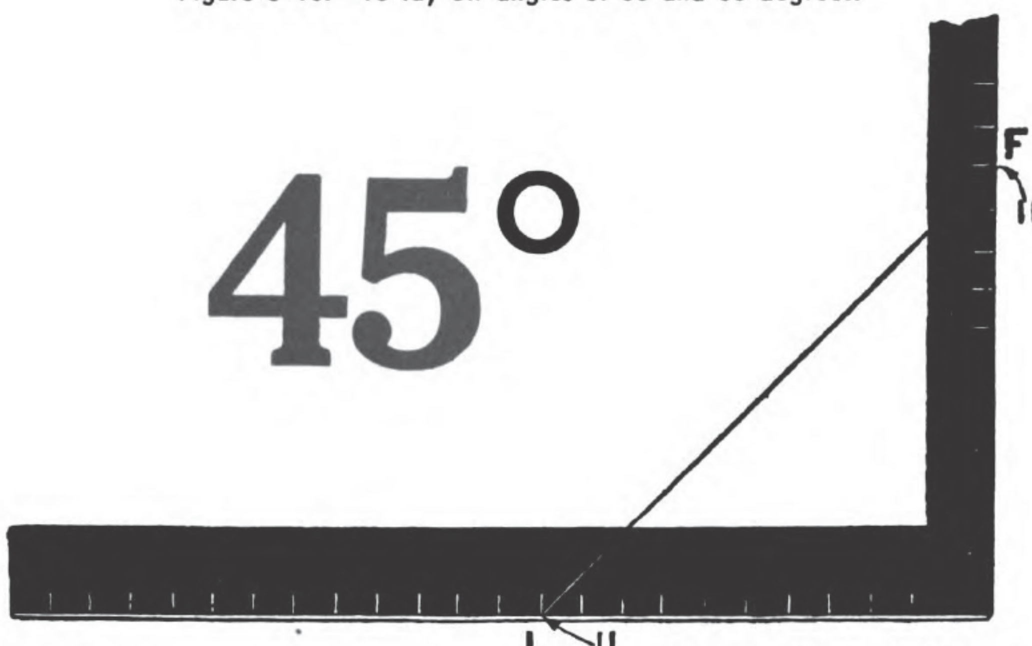
Courtesy of Sams Trade School of Correspondence.

Figure 8–9.—Steel square with scales only.



Courtesy of Theo. Audel & Co.

Figure 8–10.—To lay off angles of 30 and 60 degrees.



Courtesy of Theo. Audel & Co.

Figure 8–11.—To lay off an angle of 45°.

that *S* touches 7½ inches from the heel, as indicated in figure 8–10. The tongue will then form an angle of 60° with the line, and the body will form a 30° angle with the line.

The diagonal line connecting equal measurements on either arm of the square, forms ANGLES OF 45° with the blade and tongue, as illustrated in figure 8–11.

By using the table shown in figure 8–12, which gives values for measurements on tongue and body of the square, by joining the points corresponding to the measurements, ANY ANGLE may be laid out from 1° to 45°. Assume that you are required to lay out an angle of 37°. Place body of square on the line *FG*, as illustrated in figure 8–13, and from the table lay off on tongue *LS* = 12.04

Angle Table for Square

Angle	Tongue	Body	Angle	Tongue	Body	Angle	Tongue	Body
1	.35	20.	16	5.51	19.23	31	10.28	17.14
2	.7	19.99	17	5.85	19.13	32	10.6	16.96
3	1.05	19.97	18	6.58	19.02	33	10.89	16.77
4	1.4	19.95	19	6.51	18.91	34	11.18	16.58
5	1.74	19.92	20	6.84	18.79	35	11.47	16.38
6	2.09	19.89	21	7.17	18.67	36	11.76	16.18
7	2.44	19.85	22	7.49	18.54	37	12.04	15.98
8	2.78	19.81	23	7.8	18.4	38	12.31	15.76
9	3.13	19.75	24	8.13	18.27	39	12.59	15.54
10	3.47	19.7	25	8.45	18.13	40	12.87	15.32
11	3.82	19.63	26	8.77	17.98	41	13.12	15.09
12	4.16	19.56	27	9.08	17.82	42	13.38	14.89
13	4.5	19.49	28	9.39	17.66	43	13.64	14.63
14	4.84	19.41	29	9.7	17.49	44	13.89	14.39
15	5.18	19.32	30	10.	17 32	45	14.14	14.14

Courtesy of Theo. Audel & Co.

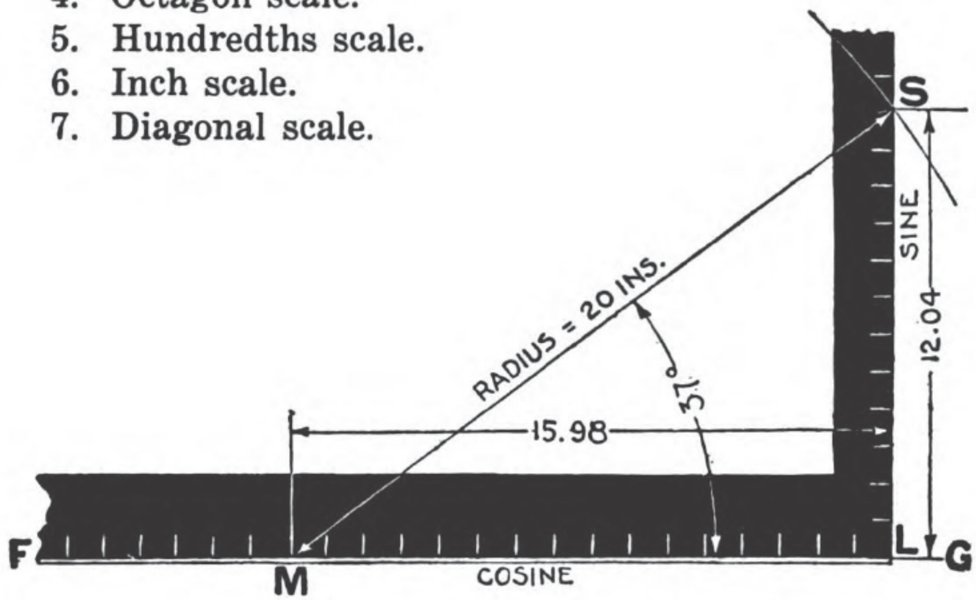
Figure 8–12.—Angle table for square.

inches, and *LM*, on body, = 15.98 inches. Draw *MS*, then you have laid off angle *LMS* to be equal to 37°. You'll observe that *MS* will be equal to 20 inches for any angle, because the values given in the table for *LS* and *MS* are natural sines and natural cosines multiplied by 20. Therefore, MS = 1 × 20.

STEEL-SQUARE SCALES AND TABLES

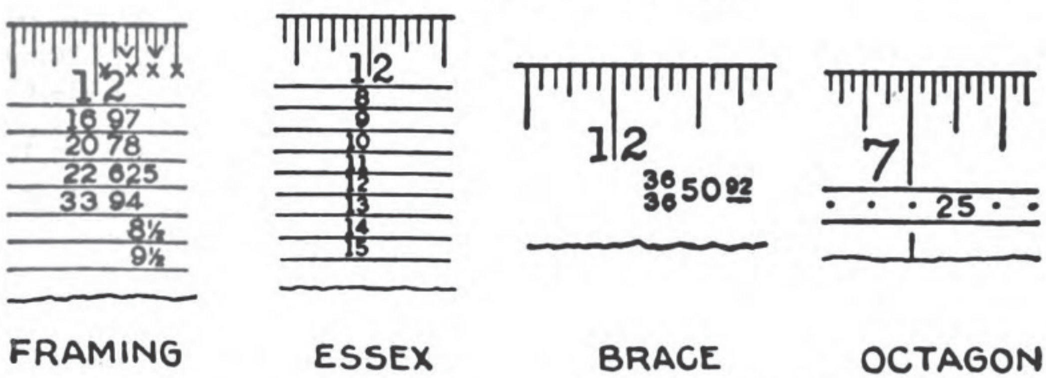
The scales and tables inscribed on a framing square which make it so valuable are:

1. Rafter or framing table.
2. Essex table.
3. Brace table.
4. Octagon scale.
5. Hundredths scale.
6. Inch scale.
7. Diagonal scale.



Courtesy of Theo. Audel & Co.

Figure 8–13.—To lay out any angle.



Courtesy of Theo. Audel & Co.

Figure 8–14.—Framing, Essex, Brace, and Octagon.

THE RAFTER OR FRAMING TABLE (see figure 8–14) shows a table, which consists of a column of six lines under each inch graduation from 2 to 8 inches. Notice that only the 12-inch section of the rafter table is illustrated. The framing table is used for determining the length of rafters and the angles at which they must be cut to fit at the ridge and plate.

THE ESSEX TABLE, or the board rule, is always inscribed on the back of the body or blade of the framing square. The Essex table shows the board measure in feet and 12ths of feet for boards one inch thick and of usual lengths and widths. The Essex table (figure 8–14 illustrates the 12-inch section), consists of eight lines under each graduation.

No set of figures on the square will be found more useful to you than that known as the board rule. Observe carefully the back of the body of the square shown in figure 8–8. You'll find under the number *12* on the outer edge of the body or blade, where the length of the boards, plank, or scantling is to be measured. The answer in feet and inches is found under the inches in width that the board, plank, or scantling measures. For example, take a board 10 feet long and 8 inches wide (see figure 8–8). Under the number *12*, on the third line you'll find the number *10*. This is the length of the board. Run along this line to the figure directly under the 8 inches (the width of the board) and you'll find 6 feet 8 inches, which is $6\frac{8}{12}$ board feet, the correct answer in "board measure." If the material is two inches thick, the sum is doubled, if three inches thick, it is trebled and so on. If the material is longer or wider than provided for by any figures shown on the square, the measurements can be divided and the results doubled.

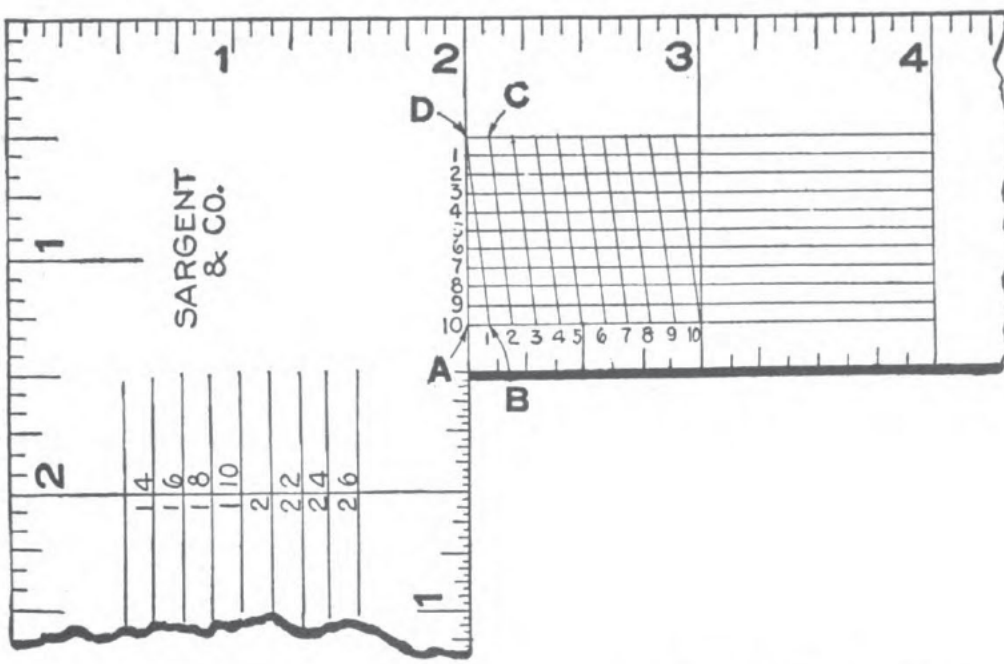
THE BRACE TABLE is found on the tongue of the framing square, a section of which is illustrated in figure 8–9. The table indicates the length of the brace to be used where the rise and run are from 24 to 60 inches and are equal in length.

Examine very carefully the brace rule illustrated on the back of the tongue in figure 8–8. The figures on the left of the line represent the "run," or the length of the two sides of a right angle, while the figures on the right represent the exact length of the third side of a right-angle triangle, in inches, tenths, and hundredths. Ob-

serving the brace table illustration in figure 8–8, you'll see that the exact length of a brace from point to point having a run of 54 inches on a post (vertical distance) and a run of the same on a girt (horizontal distance) is 76.37 inches.

You'll find the OCTAGON SCALE located on the tongue of the square, as illustrated in figure 8–14. It is used for laying out a figure with eight sides on a square piece of timber. The scale graduations are usually represented by 65 dots located $\frac{5}{24}$ of an inch apart.

THE HUNDREDTH SCALE is stamped on the tongue of the square from which measurements less than an inch may be obtained by means of dividers. You'll use this scale frequently in reference to brace measure.



Courtesy of Theo. Audel & Co.

Figure 8–15.—Diagonal scale.

THE INCH SCALES are stamped on both the body and tongue, and are graduated into $\frac{1}{32}$, $\frac{1}{16}$, $\frac{1}{12}$, $\frac{1}{10}$, $\frac{1}{8}$, and $\frac{1}{4}$ of an inch. See figure 8–8. These scales assist you in measuring and laying out work to dimension.

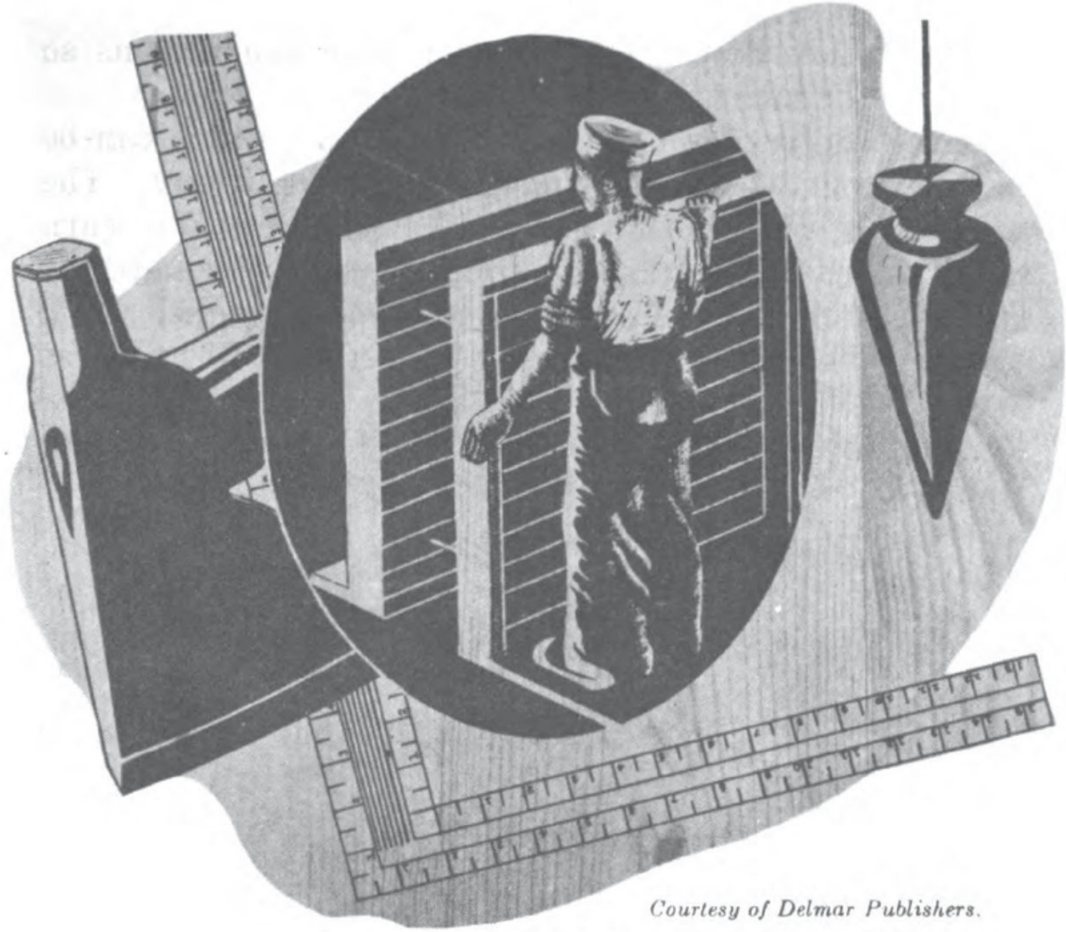
THE DIAGONAL SCALE (see figure 8–15) gives you very

small measurements without having the graduations so close together that they would be difficult to read.

There is probably no other building tool which can be used to as great an advantage as the steel square. The more experience you gain with it, the more you'll learn of the many uses it has. If you give the steel square the same attention as you would a baseball game, you'll acquire a knowledge of its simple rules. You'll find that the framing of a roof, discussed in chapter 12, is really a simple matter once you have taken a few facts from the architect's drawings.

QUIZ

1. Where will you find all the directions pertaining to "doing the job"?
2. Why should you be familiar with plumbing and electrical symbols?
3. Where is the scale always indicated?
4. Name the five types of blueprints you'll use in the construction of simple and small structures.
5. In elevation plans what do the right triangles above the roof denote?
6. What do specifications describe?
7. When is the so-called "steel" square properly called a "framing" square?
8. Name the parts of a steel square.
9. The markings on a steel square are divided into two groups. What are these two groups?
10. Name the three tables inscribed on a framing square.
11. Name the four scales inscribed on a framing square.



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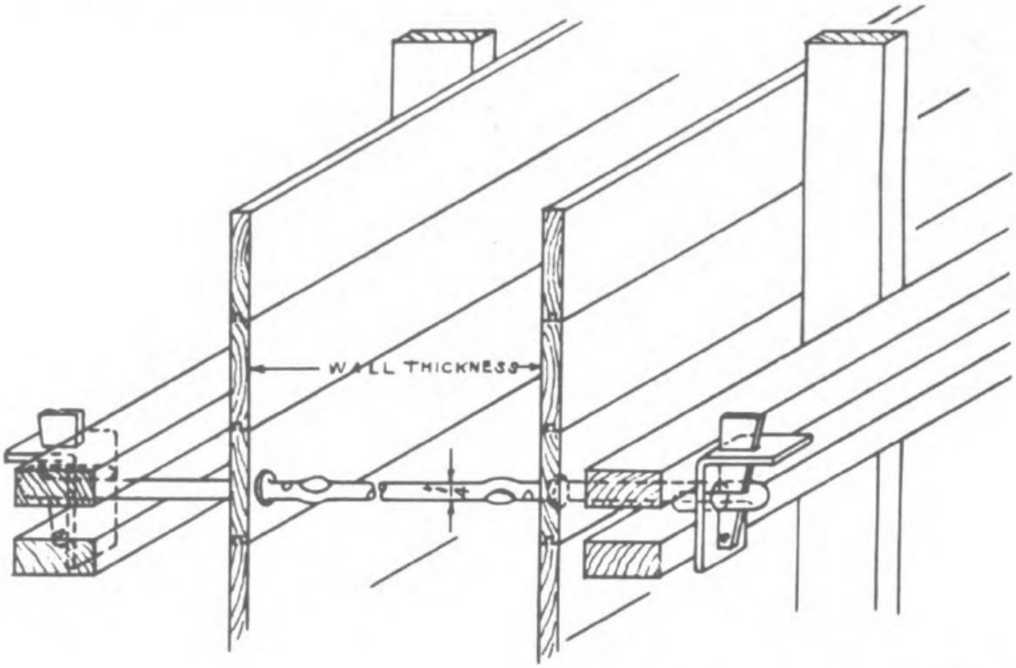
CHAPTER 9

FOUNDATION AND FORM BUILDING

GENERAL REQUIREMENTS

In order that plastic concrete may have the desired shape when hardened, it is supported in forms or molds until it has set sufficiently to be self-supporting. The economy, safety, and good appearance of a concrete structure depend on the correct design and construction of the forms. The greatest economy is obtained by constructing the forms so that they may be used over and over again in the structure, and by fastening the form together with a minimum of nailing. Double-headed nails should be used to permit a good grip of a claw bar or hammer. Wedges and clamps should be used instead of nails, where

possible, since they are more easily removed and do not injure the timber. Some of the failures of reinforced concrete construction can be traced directly to weakness in the forms due to faulty supporting work. Before any concrete is placed, the form work should be carefully inspected to be sure that the supports are strong enough, and are well braced. Forms for concrete structures should



Courtesy of Delmar Publishers.

Figure 9–1.—The use of iron plates or clips.

be tested frequently for line and level while the concrete is being placed. All form lumber should be dressed at least on one side to insure uniform thickness and on two edges to insure tight, smooth, form walls. The edges may be dressed square, tongued and grooved, or shiplapped. If only rough, nonsized lumber is available, sheet metal, plywood, or bituminous paper will give a smooth surface and prevent leakage. There are many patented devices used for holding the forms in place. One of these devices consists of bent iron plates, or clips, which fit over the edge of the walers as shown in figure 9–1. The clips are connected by wires or bolts which pass through holes

in the wings of the clips. By using different styles of clips, you can join form work of almost any shape.

TYPES OF FOUNDATIONS

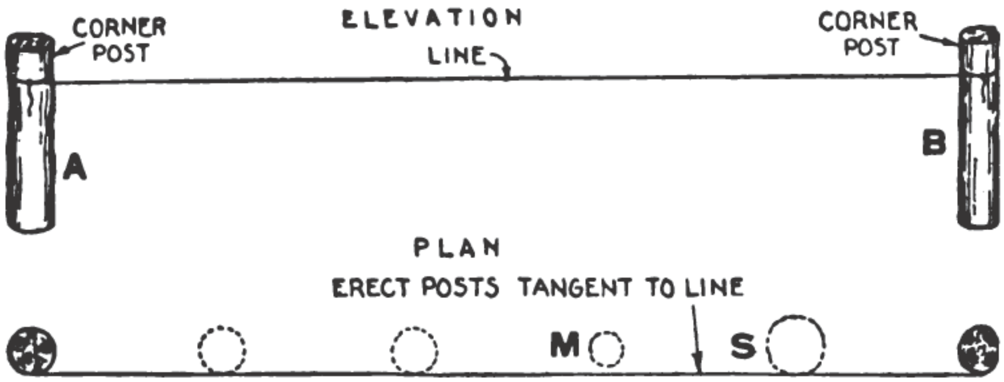
Piers, walls, or other supports below grade level are termed foundations. There are many ways in which foundations are made, and various materials, such as wood, concrete, brick, and stone, are used to make them. The architect usually indicates the locations and sizes of the footings and foundations on the plans. The types of foundations which you'll use in construction work are as follows:

1. Wood column or timber post.
2. Mud sill.
3. Concrete wall.
4. Concrete pier or column.
5. Stone wall.
6. Stone pier or column.
7. Brick wall.
8. Brick pier or column.

THE WOOD COLUMN or timber post foundation is used in overseas buildings to support 20′ x 48′ Quonset Huts, light frame buildings, and prefabricated structures. Wooden supports are easy to obtain, rapidly handled, and placed in the desired locations. Timber posts should measure not less than 6 inches in diameter at the butt end. They should be well seasoned, without checks, twists or sap, and straight and sound in every respect. It is a good rule to sink the posts into holes dug not less than three feet deep. The method of lining up posts in constructing a timber post foundation is illustrated in figure 9–2.

The first step is to locate and place in position the two corner posts as *A* and *B* of figure 9–2. Then you stretch a layout line between these posts so that it is tangent to the outside as indicated in figure 9–2. The posts to be erected between *A* and *B* should be placed tangent to

the layout line as illustrated by the dotted circles in figure 9–2. In the case of a small post as *M*, it should be moved in enough from the line to allow the centers of the posts to be in line. However, an unduly large post like *S* should not project outside the layout line but should be tangent to it.



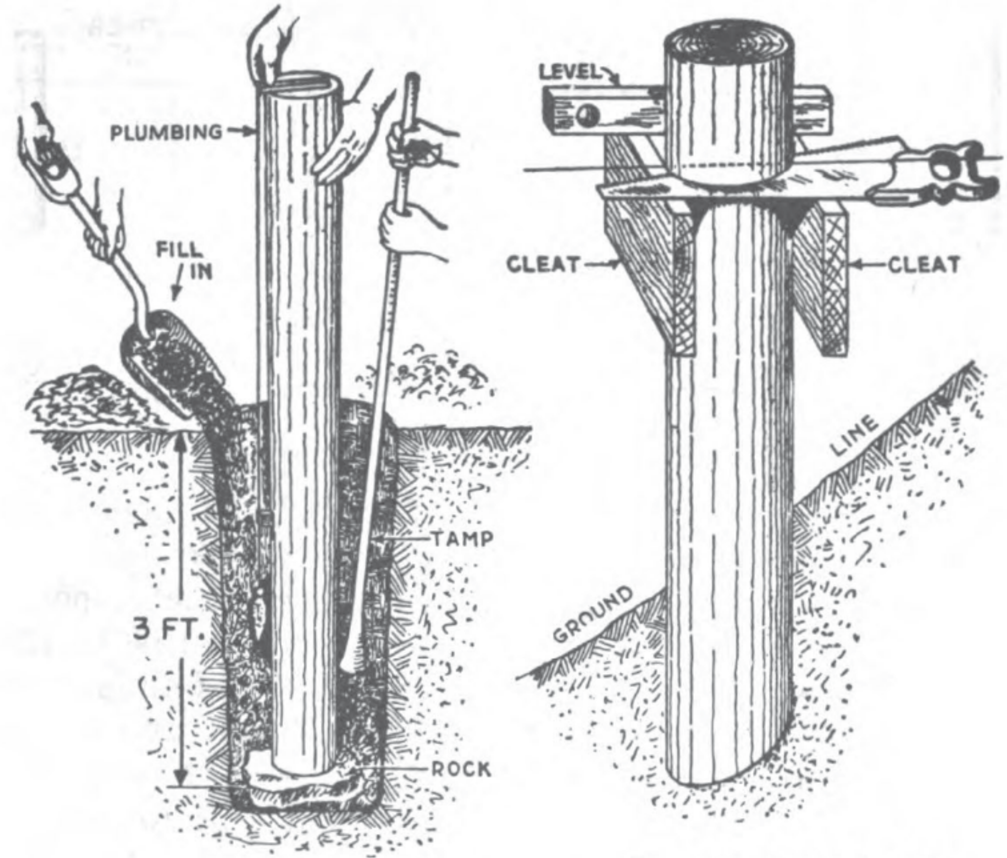
Courtesy of Theo. Audel & Co.

Figure 9–2.—Lining up foundation posts.

Figure 9–3 shows the method of erecting a timber post. If the ground or site for the proposed structure is comparatively level, you'll find that erecting the timber posts supports is an easy task, as the supports will be of the same length. However, if the ground slopes or is of a hilly nature, then the posts must be longer, and set to suit the grade as represented in figure 9–4. Notice that for this particular location, the ground dips to such a quick pitch that the seventh or last post to the left is two and a half times longer than that to the right. Also, notice that the minimum amount of post inserted below the ground's surface is 3 feet.

If obtainable, good flat stones—about the same diameter as the post-hole—should be laid in the bottom, and the post ends surrounded with small stones before filling in with soil. The filling should be done gradually, each shovelful being thoroughly rammed and solidly tamped down. At the same time, you should keep the post plumb all the way around, using a plumb bob and string to check it. In addition to setting the post on a flat stone, excellent results have been obtained by taking the bark

off the post, roughing the post a little at the bottom, and then putting in about 12 inches of fill with concrete. This anchors the foundation support so that it is not lifted by a gripping frost. Posts other than locust or cedar should be barked and treated with a preservative such as asphal-



Courtesy of Theo. Audel & Co.

Figure 9–3.—Method of erecting a post.

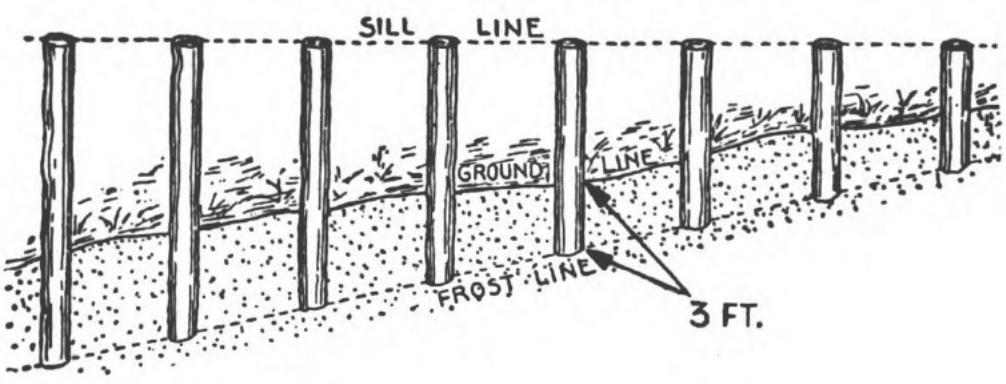
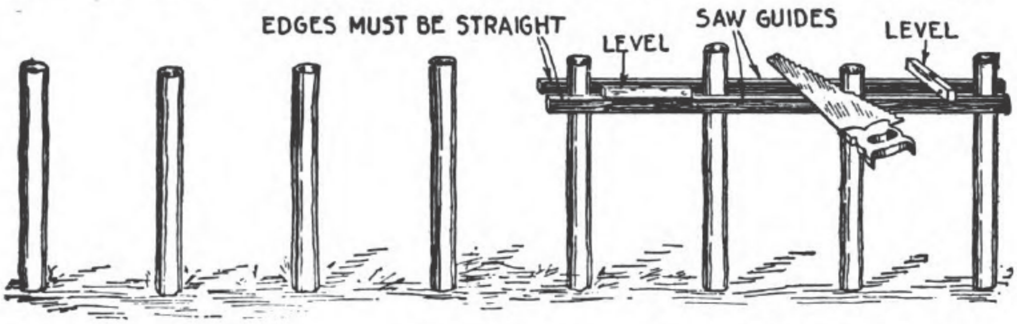


Figure 9–4.—Erecting posts on sloping ground.

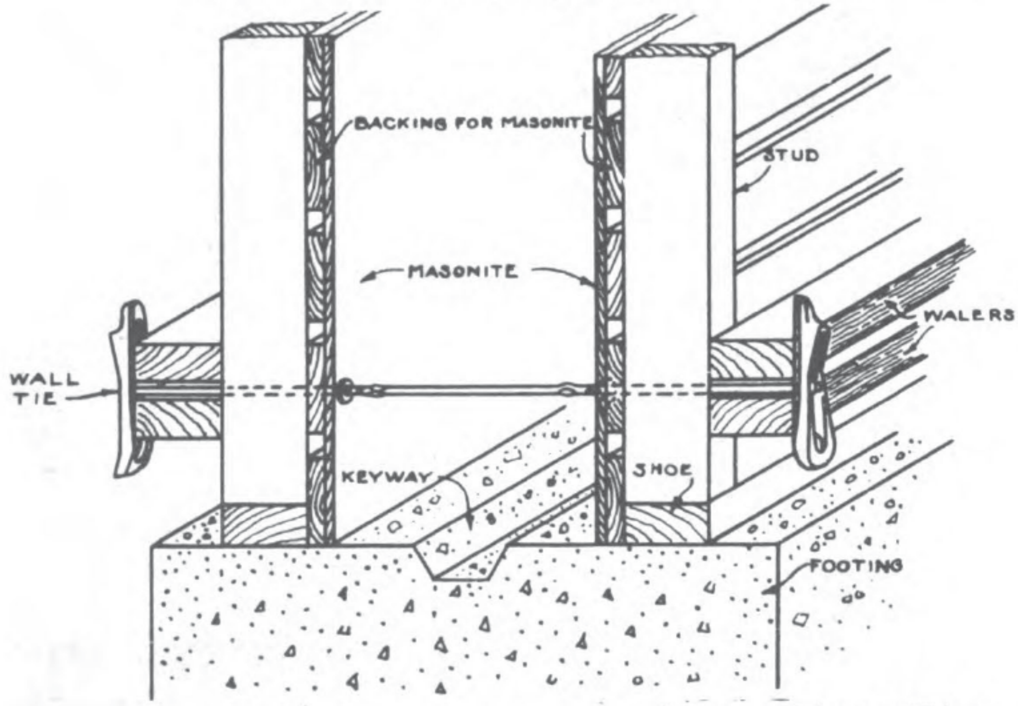
tum tar. Figure 9–5 shows a method for leveling off the tops of timber posts, with cleats to guide the saw.

The MUD SILL FOUNDATION, or floating foundation, consists of one or more timbers laid flat on the ground with



Courtesy of Theo. Audel & Co.

Figure 9–5.—Method of sawing off tops of timber posts.

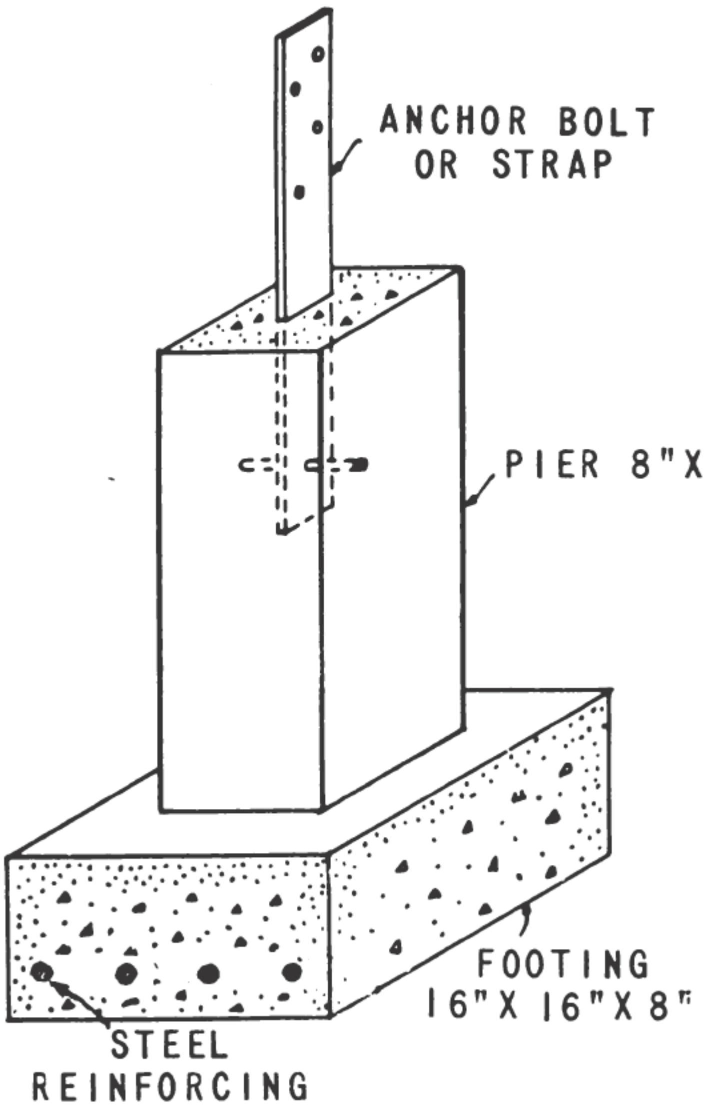


Courtesy of Delmar Publishers.

Figure 9–6.—Wall foundation.

short timbers on top in a vertical position at the bearing points. If height is not needed, the framework may rest directly on the mud sill. These foundations are used for the support of buildings and structures, when the clearance between the floor and existing ground is not necessary.

A CONCRETE WALL FOUNDATION (see figure 9–6) supports the wall, the entire length of the structure. This foundation usually consists of a footing with a wall rising in the center of the footing, forming an inverted "T." The term footing means the lower and expanded portion



Courtesy of Delmar Publishers.

Figure 9–7.—Pier or column foundation.

of a foundation which rests on the surface at the bottom of the excavation. It is made wider than the foundation wall so as to reduce the pressure (per unit area of surface) to be supported by the excavated surface, in order to reduce or prevent settling. Good construction work

requires all footings in ordinary concrete to extend 6 inches outside the face of all walls or piers. Or, the spread of the footing should be 12 inches wider than the wall or pier which it will carry, and not less than 8 or 12 inches deep. Concrete is considered the most reliable material for the construction of footings.

A common cause of foundation movement is the failure to place the footings below the frost line. If the temperature drops to below freezing before the water drains from the soil, the frost penetrates the soil deeply and thus freezes the water in the soil to a considerable depth. The resulting expansion of the soil under frost pressure causes heaving, which in turn causes foundation movement. In most cities, the building code assumes a depth of frost line for that community. Twenty to 30 inches below the surface is considered safe in most cases.

CONCRETE PIER OR COLUMN FOUNDATIONS (figure 9–7) extend into and above the ground, and support a structural member of a building. The size and shape of the concrete pier or column is governed by the weight of the structure it is to support.

STONE WALL FOUNDATIONS AND PIERS are made by placing stones of various sizes and shapes in line in a bed of mortar, and then filling the outside voids with mortar. Stone wall foundations are continuous on all sides (see figure 9–8). Stone pier or column foundations are made in the same manner, but are placed only at the bearing locations and intermediate spacings where it is necessary to support the structure. A stone pier or column is illustrated in figure 9–9.

BRICK WALL FOUNDATIONS AND PIERS are constructed by laying brick in common bond or flemish bond. Common bond is formed by 5 courses of brick laid stretchers followed by 1 course of laid headers. Flemish bond consists of alternate headers and stretchers in the same course, the header being spaced directly over the stretcher below it. Bricks are defined as to the position in which

they are placed. Thus, a stretcher is a brick laid lengthwise of a wall to bind the wall together in that direction. A header brick, on the other hand, is laid crosswise of the wall to bind the wall in a transverse direction. (See figure 9–10.)

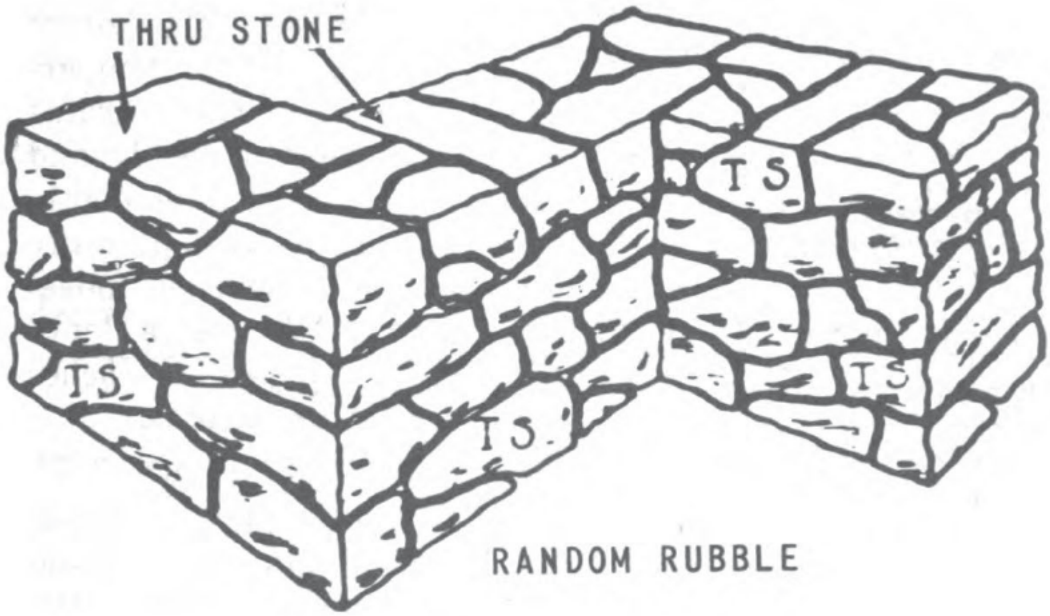


Figure 9–8.—Stone wall foundation.

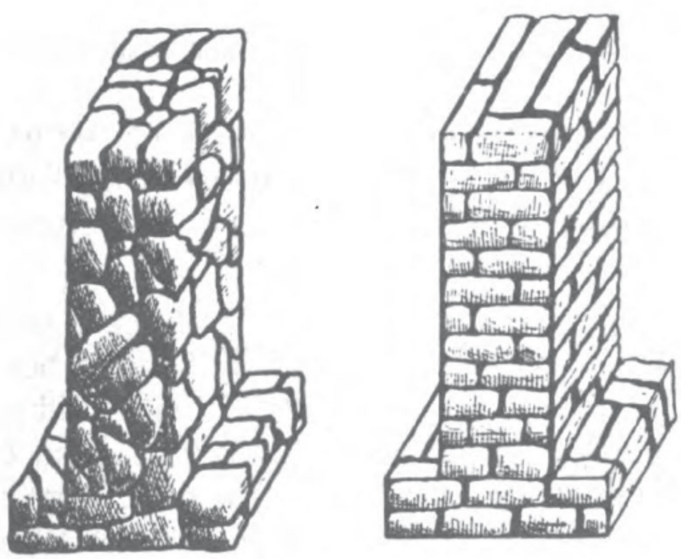


Figure 9–9.—Stone pier or column.

For most concrete work, forms constructed of wood are economical, as the wood used in these forms can be cleaned for use in subflooring, storm sheathing, or roof decking. Therefore, it is wise to use form nails in the erection of all concrete forms wherever possible, and smaller nails on boards that are nailed to the studdings. For example, you would normally use an 8d nail to make fast a ¾-inch board. However, in form building

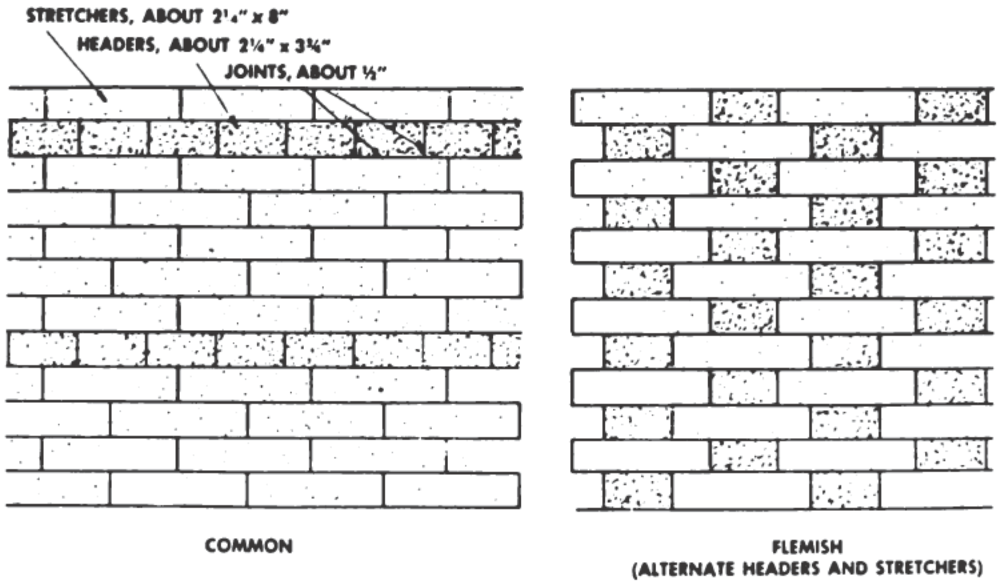


Figure 9–10.—Common and flemish bonds.

use a 6d, so you can take the form apart without splitting the lumber. Figure 9–11 illustrates a T-TYPE form suitable for foundation work.

Concrete forms should be made of semiseasoned wood. Thorough seasoned stock will warp badly when the wet concrete is placed. Spruce and Norway pine are better woods to use than hard or Georgia pine.

For ordinary foundation work, 1-inch boards may be used, the studs being placed not over 2 feet apart. These studs may be assisted materially in holding the forms in position by wires placed as indicated in figure 9–11, and by braces against the dirt wall of the excavation.

In placing the concrete, a 4-inch layer of "wet mix" is poured and then "spaded" or "worked" well into place. You get a smoother surface and avoid "honeycombing" (porous concrete) by spading the mixture away from the form. A good spading tool is made by straightening out

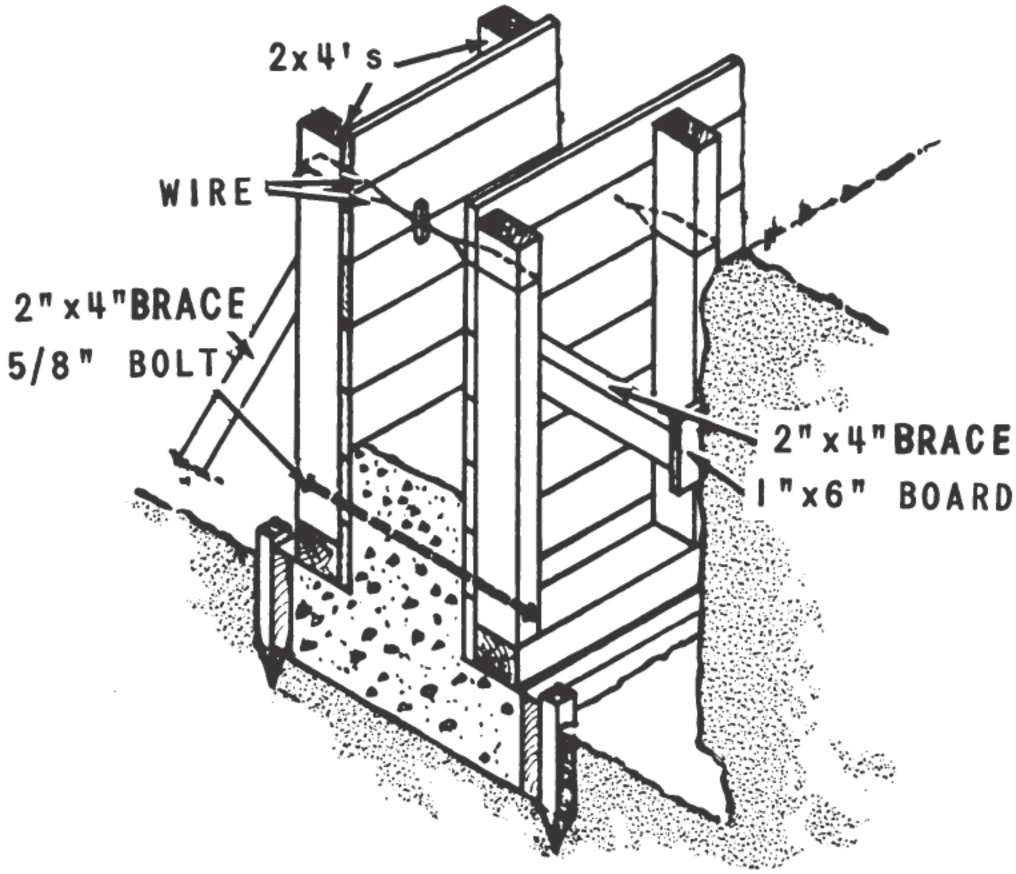


Figure 9–11.—Form for concrete.

an ordinary garden hoe. This allows the cement and mortar to flow next to the form and hold it in place while the filling proceeds. Concrete forms for ordinary walls should be allowed to remain until the concrete will resist indentation with the thumb.

You should always paint the interior surfaces of a concrete form with a lubricant such as form oil, stainless grease, soft soap, or white wash, before pouring concrete. The lubricant prevents the concrete from sticking to the form. Forms must be tight, rigid, and strong enough to stand the weight of the concrete. In designing vertical

form members, you can figure pressure of fresh concrete at 150 pounds per square foot, per foot of height. Concrete should be poured in slowly with the use of chutes or "tremies" in order to keep the heavy aggregates bound together with the cement, and to keep from wrecking your forms.

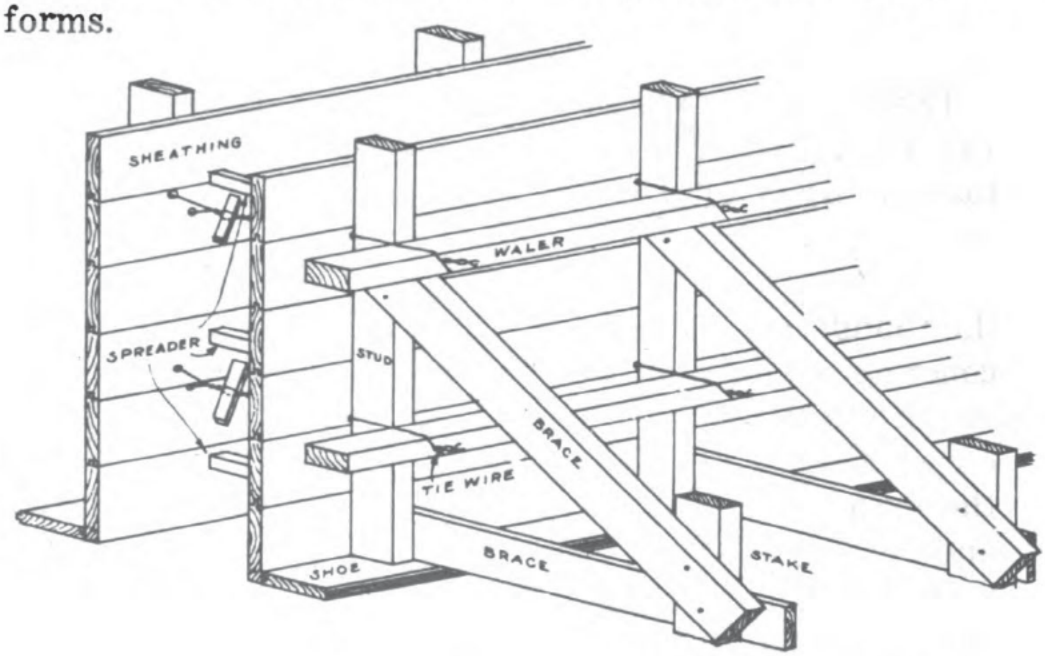


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Figure 9-12.—Form for a concrete wall.

Careful observation and study of figure 9-12 will acquaint you with concrete form members and their functions. The SHOE acts as a plate to hold the studs at equal spacing and as a straight edge to the form. The STUDS form a solid backing for the sheathing and hold it in alinement. The WALERS hold the panels of the form in a straight line and provide rigidity and bracing. The SPREADERS hold the forms the proper distance apart until the concrete has been poured. The WIRES hold the panels against the spreaders, thus keeping the forms from spreading apart under the pressure of the wet concrete. The wires are twisted to draw and hold panels tightly against the spreaders. The BRACES hold the form in an upright or solid position and prevent the form from moving under the pressure of the concrete. The STAKES

give nailing support for the braces. Whenever two braces are necessary on the same stud to keep the form secured, both braces should be made fast to the same stake in order to permit easy access to the form.

TYPES OF BUILDING FORMS

There are various designs of building forms such as: (1) L-type; (2) T-type; (3) Manhole forms; (4) slab-forms; (5) column forms; and, (6) reinforced concrete building wall forms.

The L-TYPE FORM gets its name from the L formed by the foundation wall and the footing. That portion of the concrete wall below the surface of the ground may not require forms for both sides of the wall. This will depend on whether or not the ground is porous. If the bank of the excavation is firm, it may serve as the outer form, and the L-type form serves as the inner wall. This type of form should be avoided whenever possible, as it is very difficult to cut the banks straight and plumb. If the banks are not straight and plumb, you'll have to use more concrete, and the wall will be more expensive. Without an outside form, no wall ties can be used. Therefore, this type of construction requires heavier bracing on the inside wall to compensate for the lack of wall ties.

The T-TYPE FORM (see figure 9–13) is frequently used to form and make both wall sides and the footing at the same time. With this type of form, which has a complete inside and outside form, a reasonably straight smooth wall is possible. Forms should be built in sections not too heavy for four men to lift. They should be erected and secured in such a way that they can be removed from the hardened concrete wall without an excessive amount of hammering or pulling, which might crack or deface the concrete. After the form sections have been made, they should be braced in position by walers and spreaders and held to alinement by diagonal bracing. Referring to figure 9-12, you'll notice that a spreader is a small block

(usually $\frac{3}{4}''$ square, and as long as the wall is thick) placed near the wire in order to maintain the proper distance between the walls until the concrete has been poured. The spreaders must be removed as the concrete is poured into the forms. You'll have to be careful when

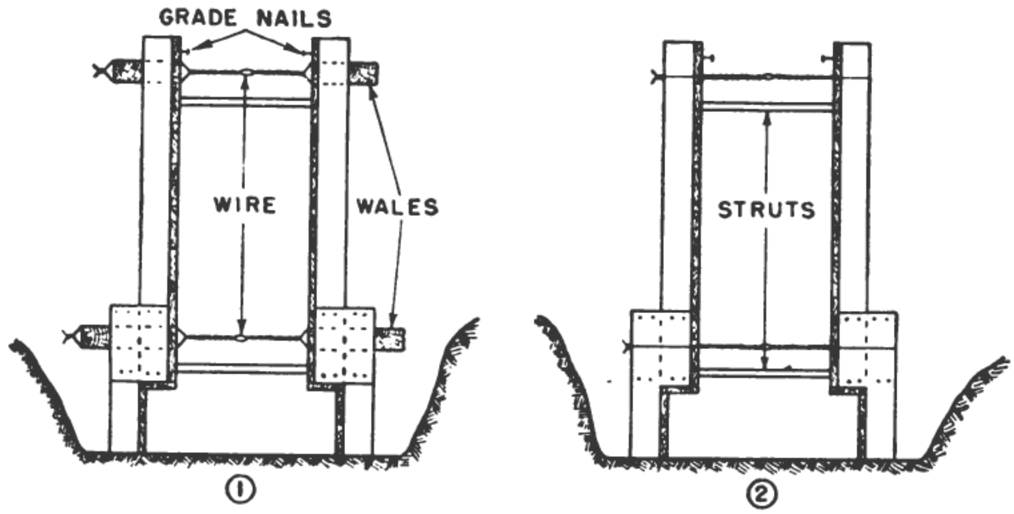

Figure 9–13.—Double wall or T-type form.

you are twisting the tie wires that hold the forms against the spreaders, in order to keep from breaking the tie wires. Too much twisting stretches the wire close to its yield point, and it's likely to break under the pressure of the concrete load.

MANHOLE FORMS are constructed in various designs. The types generally used overseas during World War II were either the hexagon (six side walls) or the octagon (eight side walls) form. They are used in pouring manholes, which are collecting stations for underground water or sewage disposal systems. Figure 9-14 illustrates a typical manhole section.

The excavation should be made about 2 feet larger on all sides than the actual size of the proposed manhole. The additional 2 feet of space will allow you sufficient working space and, at the same time, you'll be able to place the outside form bracing against the excavation wall. After the required depth has been obtained in accordance with the plans, the concrete deck or slab of the manhole is

placed. The slab should be made with joining strips in order to connect the sidewalls with the deck, thereby making the joints waterproof. This joining is made by installing a key in the concrete slab. Steel reinforcing should also be used in the slab to bind the side walls to the concrete deck of the manhole.

COLUMN FORMS are used to make concrete posts that are used for supports of a structure and are frequently

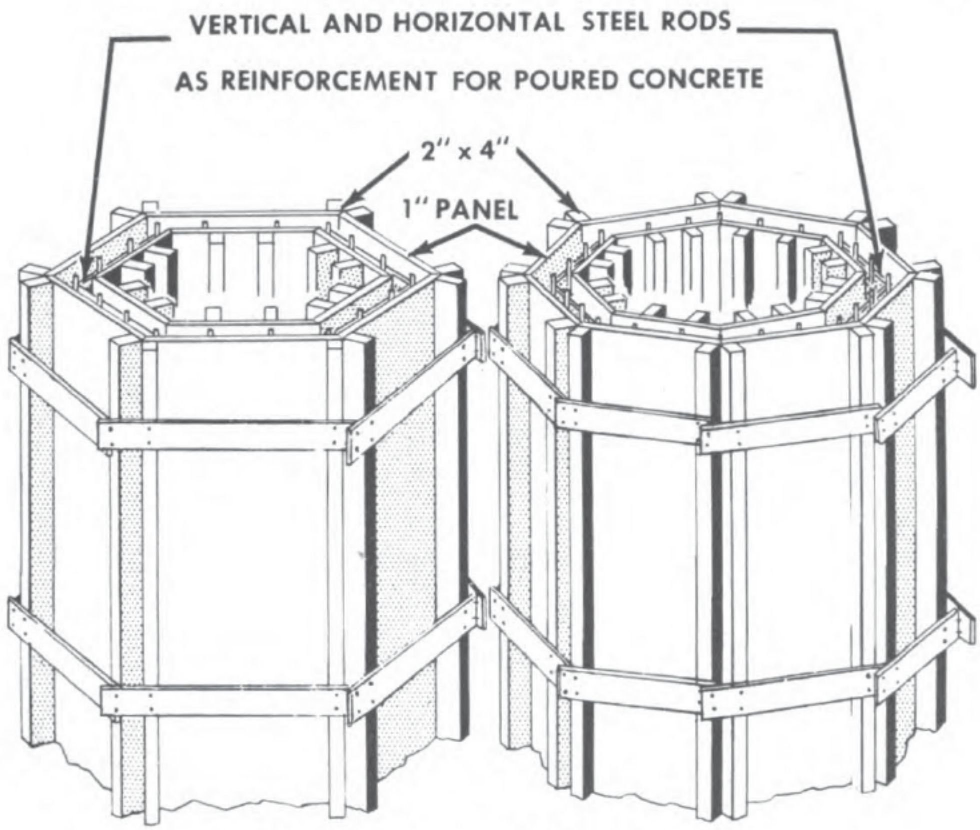

Figure 9-14.—Manhole section.

used to reinforce side walls. Observe carefully the column forms shown in figure 9-15.

REINFORCED CONCRETE BUILDING WALL FORMS are used to construct concrete sidewalls of a building. These form walls are used more than once, and should be constructed in such a manner that they may be easily removed without damage. The inner sides of these wall forms are installed first. Then the reinforcing steel and frames for the

window and door openings are placed. Finally, the outer side wall form is placed, tied, and braced for the concrete pour.

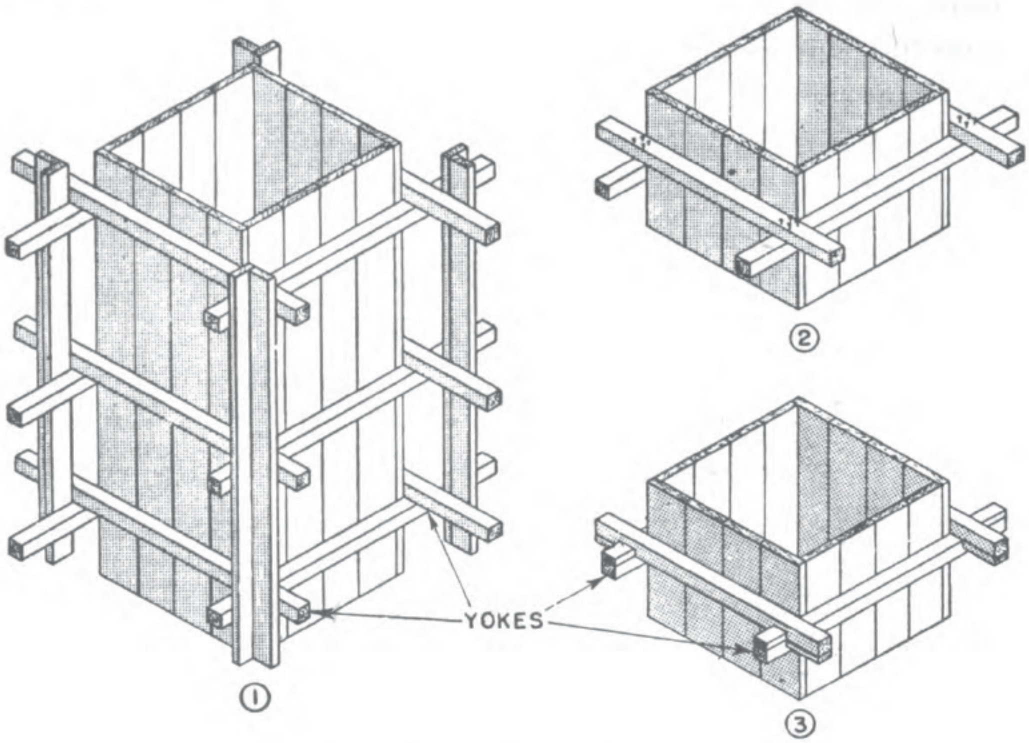

Figure 9-15.—Column forms.

BONDING A WALL TO A FOOTING

You'll readily see that some provision is necessary for tying the wall above to the footing below, particularly where one side acts as a retaining wall. Figure 9-16 shows you a footing keyed to the wall. If no such provision is made, there will be a tendency for the wall to be pushed off the footing, because of the pressure of the earth on one side with nothing on the other side to counteract it. A keyway is installed in the center of the footing to prevent this. The keyway is made by pressing a slightly beveled 2 x 4 into the concrete while it is still wet and then removing it when the concrete has set (figure 9-17). Reinforcing rods may also be used to fasten a wall to a footing. In cases where the footing and the wall can be poured

together, rods are frequently used to strengthen the bond between the wall and the footing.

Forms for footings are not always necessary, as the banks of the excavation can serve as walls to mold the concrete mass. When foundation walls of only several

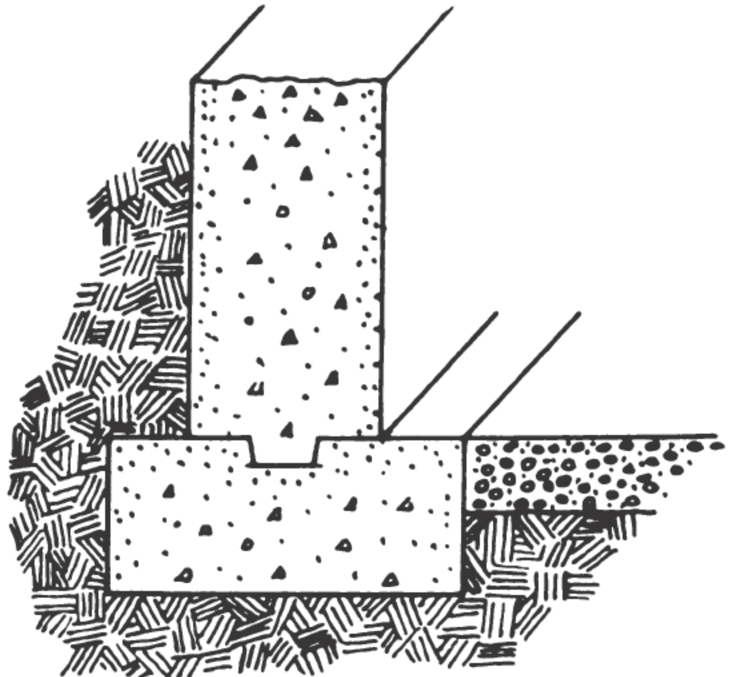

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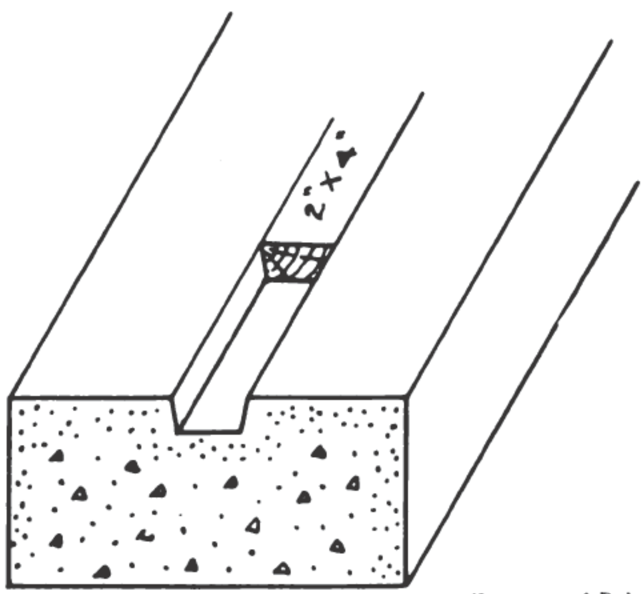
Figure 9–16.—Footing keyed to the wall.



Courtesy of Delmar Publishers.

Figure 9–17.—Method for making keyway.

feet in height are necessary, the footing and the foundation wall are poured in one operation. The wall forms are secured in place by braces that extend from the wall form side to stakes outside of the excavation. The concrete is poured into this form, and is allowed to spread in the excavation, thus forming the footing for the foundation wall and the foundation sidewall in one operation.

BACK-FILLING

After foundation walls have been completed, the earth previously excavated must be filled in against the outer sides up to the level of the ground. Many new walls have been sprung, sometimes so badly that it is necessary to rebuild these walls because of improper back-filling. Frequently, heavy walls are thrown down by filling in with earth between the wall and the inclined bank of the excavation, causing a sliding pressure against the wall as the fill and weight increase. The simple remedy is to level and square the sides in step courses as you make the fill. The proper method of filling is illustrated in figure 9-18. This prevents the wedging action which would be present if the side of the excavation were sloping as indicated by the line *MS*. You'll notice that the fill is partly supported by the series of steps, rather than being wedged against the wall, when the side of the excavation slopes outward as indicated by the line *MS*.

SAFETY PRECAUTIONS IN FORM BUILDING

When excavations over 4 feet are made, the sidewalls should be braced sufficiently to prevent a cave-in. Never use the wall forms as a means of crossing the excavation. You should always be alert when working around excavations and foundations. Particular care should be exercised so that you'll not trip on the stakes supporting the form braces. As you dismantle forms, always remove all nails immediately. Steel bars, used in reinforced con-

crete, are tied with wires. These wires have sharp ends, so you should be extremely careful when working between these bars.

FINAL PREPARATION OF FORMS

Before concrete is placed in forms, you should always remove all debris, such as sawdust and shavings. All

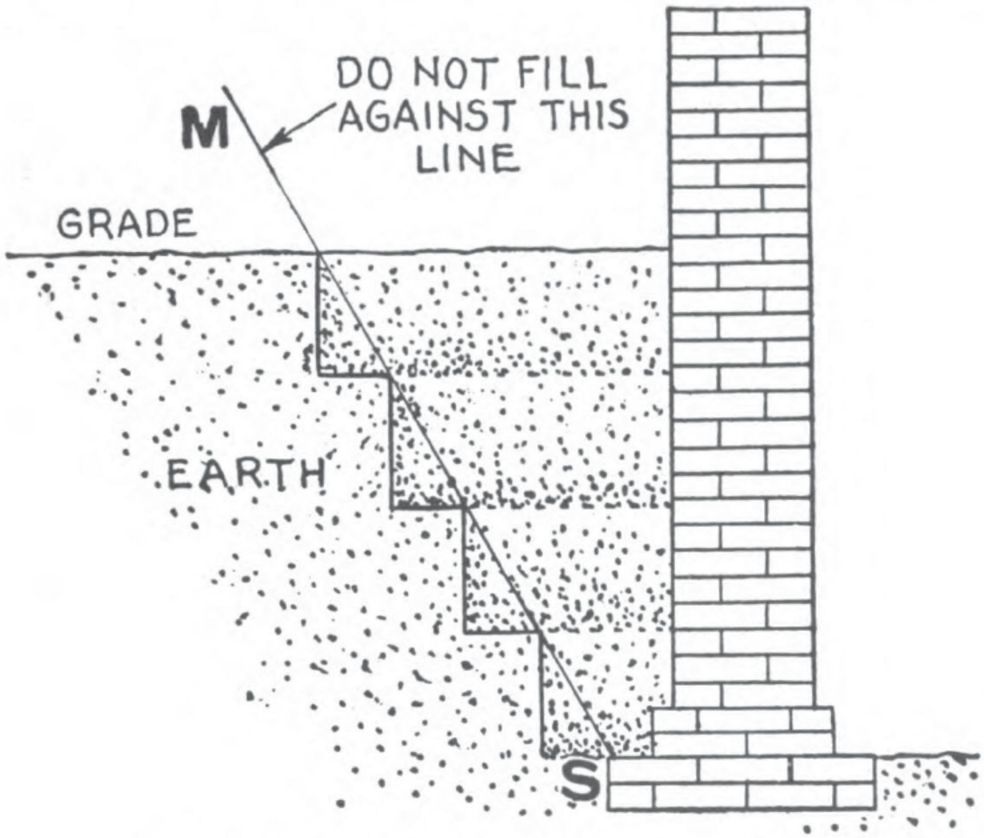


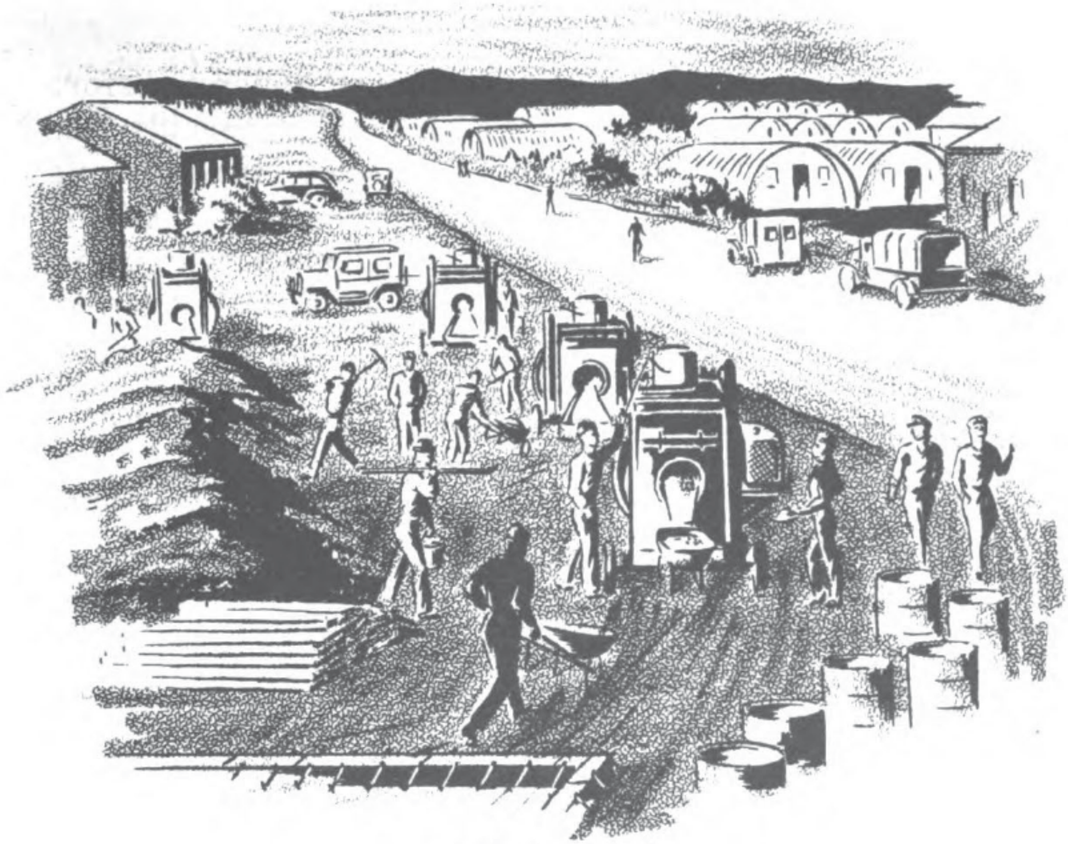
Figure 9–18.—Method of back-filling against wall.

knotholes, or other holes in forms should be patched with sheet metal, waterproof paper, or putty, depending upon their size. If form material has been used previously, all dry concrete must be removed from inside of forms. You should always apply a lubricant to forms, before the concrete is placed, to prevent concrete from adhering and to aid in their removal. You should exercise care in lubricating the forms, in order to keep form oil off the reinforcing steel. It is vitally important that you allow

sufficient time for the proper hardening of concrete before removing the forms. Leaving forms in place aids this hardening process by preventing concrete from drying out and, in cold weather, by insulating the concrete. Always observe the basic rule in removing concrete forms, "It is better to leave forms in place too long than to remove them too soon."

QUIZ

1. In form work, before any concrete is placed, why should the form work be carefully inspected?
2. Why should all form lumber be dressed at least on one side?
3. In overseas buildings, what is the wood column or timber post foundation used to support?
4. What does the term footing mean?
5. Brick wall foundations and piers are constructed by laying brick in two methods. Name these two methods.
6. How is a header brick laid?
7. What lubricants may be used for painting the interior surface of a concrete form?
8. Why is a keyway installed in the center of a footing?
9. When excavations are made over four feet, why should side-walls be sufficiently braced?
10. What is the basic rule to observe in removing concrete forms?



CHAPTER 10

CONCRETE

CEMENT, THEN AND NOW

In ancient times, the Romans used volcanic ash and quicklime to manufacture a durable cement. However, little was known of the chemical composition of cements and limes until the year 1756, when a building engineer discovered that a hydraulic cement could be obtained by burning a certain limestone, which closely resembled clay.

With the discovery in 1818 of a natural cement rock in New York, the cement industry began in the United States. The first portland cement was produced in 1875 near Allentown, Pennsylvania. This location, now known as the Lehigh District, produces a large quantity of portland cement today. The word "portland" refers to a type of cement, not to a trade name or brand. It resembles the color of the gray limestone quarried on the Isle of

Portland, England, and for that reason is called portland cement. Today, the term portland cement designates the common, gray cement that is used throughout the world to make concrete or mortar. There are many types of cement; however, standard portland cement and high-early-strength cement are the two classes most commonly used in the Construction Battalions. Standard portland cement is used for all concrete work when sufficient time is available for it to develop its full strength, while high-early-strength cement is used for construction work which must be completed in a short time. Concrete made with high-early cement will develop within three days about 75% of the strength developed in 28 days by concrete made with standard portland cement. Cement is usually shipped in bags or barrels. A bag of cement contains 94 pounds, and is one cubic foot in size. A barrel contains four bags of cement. When cement is delivered on a construction job, it is very important that you keep it dry until used, for it will set when exposed to moisture, and particles that have set cannot be restored to a plastic condition. It is also important to protect cement from excessive heat, as hot cement may become quick-setting. Therefore, cement should be carefully stored in a waterproof structure at least eight inches from walls, ground, or floor.

CEMENTING MATERIALS AND AGGREGATES

MORTAR is a mixture of sand, water, and a cementing material, in proper proportions. In hardening, the cementing material binds the particles of sand together and forms a solid mass. Bricks and stones are bound together by laying mortar between them.

CONCRETE consists of broken stone, gravel, cinders, or slag mixed with a mortar of sand, cement, and water. This mixture can be poured into molds or forms, and on hardening will take the shape of the moid. Concrete is used in all kinds of construction. When it is used in combination with steel rods, it is known as reinforced concrete.

AGGREGATE is the term applied to the inert materials which are bound together with cement to make concrete. Fine aggregate consists of particles $\frac{1}{4}$ of an inch in size and smaller. Particles larger than $\frac{1}{4}$ of an inch constitute coarse aggregate. Natural sand and crushed-rock screenings are commonly used for fine aggregates. Stone screenings are frequently used instead of sand with satisfactory results, provided they come from hard, durable rock and are well graded, clean, and free from an excess of dust.

Sand, to be used in concrete, should be clean and sharp, without any admixture of clay, loam, weeds, or fine dust. These foreign materials prevent good bond between the cement and sand, and result in a loss of strength. River-bank sand that contains mud or slime should not be used, because its greasy nature prevents proper bonding with cement. Seashore sand is also unsatisfactory, because its sharp edges have been worn dull. The stone used as coarse aggregate is obtained by crushing rock in a rock crusher or by hand. The shape of aggregate particles, particularly of coarse aggregate, has some effect on the density and workability of concrete. Flat particles pack loosely and, therefore, are less desirable than those of somewhat cubical shape. Also, angular particles become compact more firmly and more readily than round particles, therefore making the best concrete bond.

The size of the coarse aggregate used depends upon the type of work. For thin walls or construction where the concrete must be worked around reinforcing steel, the aggregate should be graded up to 1 inch in size. Large mass concrete may use sizes graded up to, and including material of 3 inches in average diameter. The best concrete is produced when the coarse aggregates are graded in size, that is, when they vary in size from fine to coarse, so that the mass may run together evenly when mixed. If the only aggregates available contain objectionable foreign materials, such as clay and silt, they must be washed before use. A convenient field test for the pres-

ence of silt and clay in excess quantities is as follows (see figure 10–1) : Fill a quart jar to a depth of 2 inches with a sample of sand; add water until the jar is 3/4 full; shake for one minute, and allow the jar to stand one-half hour. If there is more than 1/8 of an inch of sediment on top of the sand after settling, the sand is unsuitable unless excess silt and clay are removed by washing. There are several simple devices for washing and screening such aggregates. One such device for washing sand and gravel with high silt content is shown in detail in figure 10–2.

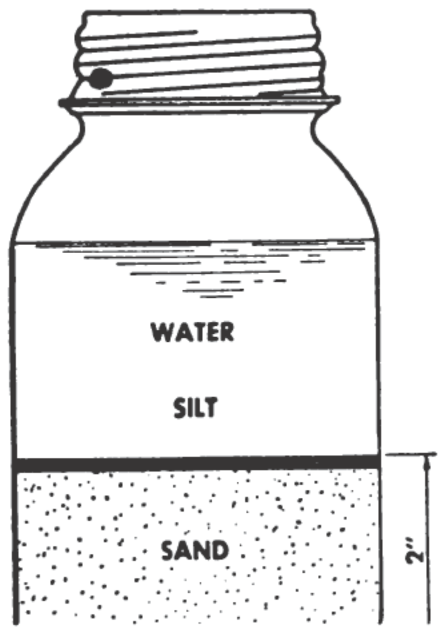


Figure 10–1.—Quart-jar method of determining silt content of sand.

WATER in a concrete mixture unites chemically with cement to form a hard binding material between aggregate particles. Water serves as a carrying medium for cement, and makes it plastic during mixing and placing. Water used for concrete should be clean and free from excessive amounts of oil, acid, alkali, organic, or other objectionable matter. Sea water is undesirable and should not be used except in an emergency. In general, only water that is fit to drink will make good concrete.

WORKABILITY

Fresh concrete that has a plastic consistency so that it can be readily worked into place without segregation of aggregate particles or accumulation of free surface water, is said to be workable. Consistency is varied to suit construction requirements. Stiff consistency (figure 10–3 (1)) is suitable for mass concrete such as pavements, foundations, floors, and heavy walls. Medium consistency (figure 10–3 (2)) is suitable for reinforced walls, slabs,

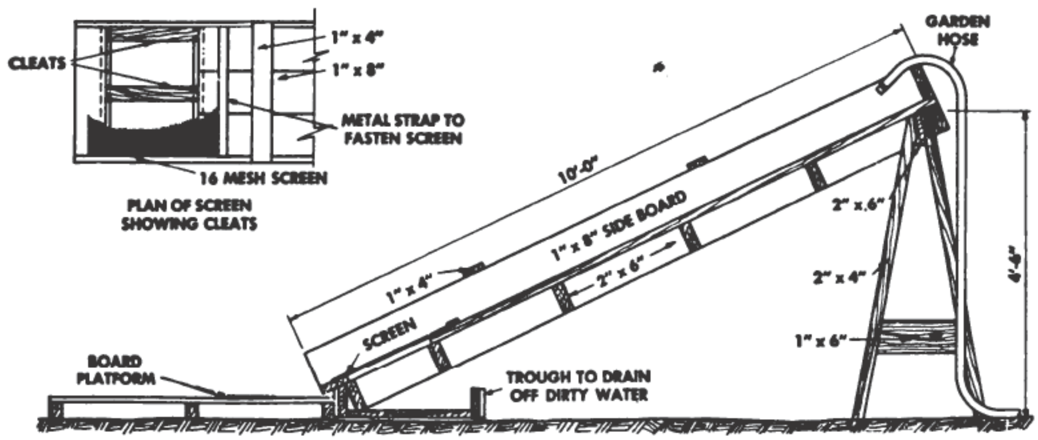


Figure 10–2.—Device for washing sand and gravel with high silt content.

and beams. Fluid consistency (figure 10–3 (3)) is used for heavily reinforced sections, thin walls, and columns. Good workability results from well-graded aggregates and proper ratio of fine to coarse aggregate. Gradation of fine aggregate has very marked effects on workability.

SLUMP TEST

The slump test is the standard method used to measure consistency and workability of fresh concrete. A conical shell with a base 8 inches in diameter, top 4 inches in diameter, and a height of 12 inches, is filled to overflowing with a sample of freshly mixed concrete. The concrete is

rodded into the shell in three separate layers, each layer receiving 25 strokes with a bullet-jointed steel rod $\frac{5}{8}$ inch in diameter and 24 inches long, as shown in figure 10–4. The mold must be held down firmly during filling and rodding. The excess concrete should be struck off

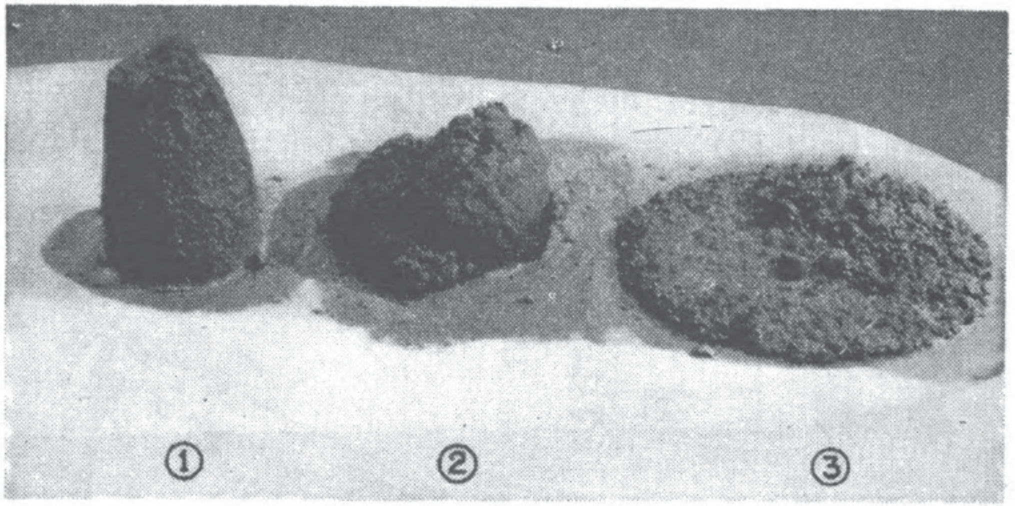


Figure 10–3.—Illustrations of consistencies of fresh concrete. (1) Stiff. (2) Medium. (3) Fluid.

Figure 10–4.—Rodding the top layer of concrete in the slump mold.

carefully, and the mold lifted slowly and vertically. The drop or slump of the mass of concrete is then measured below the original 12-inch height, as indicated in figure 10–5. The slumps for various kinds of concrete are shown in the table—figure 10–6.

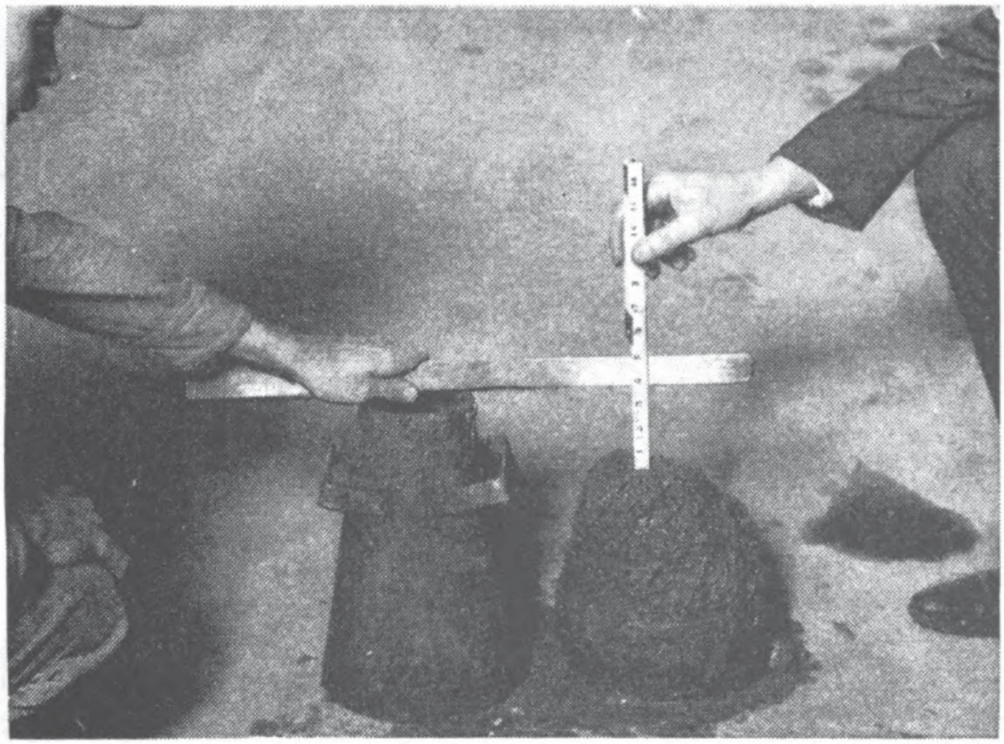


Figure 10–5.—Measuring the slump after removing the mold.

PROPORTION OF MATERIAL

To insure good concrete construction, it is necessary to state the exact amount of mixing water for each bag of cement, according to the type of work. It has been found that close attention to the WATER-CEMENT RATIO will more than repay the little extra effort involved in measuring the water accurately. The underlying principle of this method may be stated as follows: For plastic mixes using sound aggregates, the strength and other desirable properties of concrete, under given job conditions, are governed by the net quantity of mixing water used per sack of cement.

Gallons of water, including surface water in aggregate, for each sack (94 pounds) of cement used. Strength values are minimum 28-day compressive breaking strengths in pounds per square inch that may be expected under ordinary conditions.[1]

Type of work or structure		Condition of exposure or wear		
		Subject to severe wear or weather conditions, alternate freezing and thawing, exposure to sea water or weak chemical solutions, etc.	Subject to moderate wear or weather conditions; or for watertight concrete	Protected from wear and weather; not subject to moisture and alternate freezing and thawing, nor to corrosive ground waters, etc.
Heavily stressed concrete. Structural members and protective structures.	Water-cement ratio	5½	6	6½
	SPC [2]	3,750	3,400	3,000
	HE [3]	4,500	4,000	3,750
Moderately stressed structures. Pavements, basement floors, retaining walls, etc.	Water-cement ratio	6	6½	7¼
	SPC	3,400	3,000	2,500
	HE	4,000	3,750	3,200
Mass concrete; heavy walls, piers, foundations, dams, etc.	Water-cement ratio	6½	7¼	8
	SPC	3,000	2,500	2,000
	HE	3,750	3,200	2,700

[1] Allowable compressive working stress in bending is 50 percent of strength values given in this table.

[2] SPC—Standard portland cement concrete strength value.

[3] HE—High-early-strength cement concrete strength value.

Figure 10–6.—Slumps for various kinds of concrete.

No one formula for mixing concrete to meet the entire range of conditions of stress, wear, watertightness, and economy demanded in various kinds of construction work may be given. Specifications will generally list the quantities of water for different classes of work as well as the proportions of cement to sand and coarse aggregate. The proportion of other material to concrete is usually given by volume. Cement is measured by the bag, which contains 1 cubic foot, and the aggregates in cubic feet. Water is measured by the U. S. gallon. It is a standard practice to designate a concrete mix by three numbers, such as 1:2:3. The first number always refers to the number of bags of cement; the second number is the number of cubic feet of fine aggregate (usually sand); and the third is the number of cubic feet of coarse aggregate, such as pebbles, crushed stone, or cinders.

MIXING CONCRETE

Concrete is generally mixed in batches; that is, a batch composed of measured quantities of cement, water, and aggregates is assembled, mixed, and removed to the forms. A batch usually contains a whole number of full bags of cement and is referred to as a one-bag batch, a two-bag batch, and so on, as the case may be. There are two methods of mixing concrete; namely, hand mixing and machine mixing. Excellent concrete can be mixed by hand, although machine mixing is preferred because better quality concrete results.

If you mix the concrete BY HAND, use a watertight platform about 10 feet wide and 15 feet long. Spread the sand over the surface, add the cement, and mix thoroughly while dry. Then, add the water and aggregate, and turn the whole mixture back and forth until it becomes homogeneous. About five complete turnings are usually necessary.

The most common type of mixer that you'll have at advanced bases and training bases in the States is the

7 S. This MACHINE is a portable mixer and has a 7-cubic-foot capacity mixing drum. It is one-man operated with an automatic metering water tank. The mixer is powered by a 15-horsepower, air-cooled gasoline engine, which has a power take-off that raises and lowers the skip and operates the shaker. This shaker is so-called because of the action it takes in cleaning the skip. The skip is the container in which the material is placed prior to the mixing and is used to measure the material. The material is then raised in the skip by means of a cable on a power drum. Raising the skip causes the material to fall into the mixing drum. The mixing process varies in time according to the desired mix. The minimum time for a mixer of this size to turn enough revolutions to thoroughly mix the contents is 1½ minutes. Caution should be taken to use the proper amount of water for the mix at hand.

CONCRETE DECKS

For concrete decks a standard mixture is 1: 2: 3½—which means that one part cement is mixed with two parts of sand and three and a half parts of suitable aggregate. This is a good mixture to use for reinforced floors and for engine and machine foundations. For floors on the ground, supporting ordinary machinery, a good mixture is 1: 2½: 4. A lean mixture 1: 3: 5 may be used for heavy floors which are to support a steady load.

You should use approximately six gallons of water per bag of cement. Only about three gallons are needed to set the cement, but the mixture would be so thick that it would be difficult to handle. On the other hand, if too much water is used, the mixture will be filled with trapped-water pockets which will weaken the resulting concrete. You'll find that the amount of water will vary according to the quantity of water contained in the sand; that is, if the sand is wet, you'll use less water. If it is dry, you'll need more water.

Never permit the mixed concrete to stand before being used. Transport it directly from the mixer to the forms. Even if it is allowed to stand a short while in a wheelbarrow before being poured into the forms, the aggregate will settle appreciably, and the concrete will lose its homogeneity. Concrete which has remained in a wheelbarrow long enough to begin to set, should never be restirred and used. Such action would produce a very poor grade of concrete with very little strength.

Be sure to tamp the concrete well when it is poured. This works it down into the corners of the forms and around the steel reinforcement. Tamping, also termed spading or puddling of the concrete, is necessary to cause the concrete to spread towards the form sidewalls after it has been deposited in the forms. In recent years, vibrators have been used to aid in the flow of the concrete in the forms. They are operated either by compressed air, electricity, or by a small gasoline engine, and can be used both internally and against the outside of the forms. On large jobs, these small machine-driven vibrators are fastened to the forms and shifted from time to time after the concrete appears to have settled as far as possible. Vibrating the forms, after they have been filled, is an excellent way to prevent voids or air pockets.

To finish the surface of a concrete deck, use a long wooden float, moving it back and forth over the top of the concrete to work the large particles beneath the surface. After the excess water has disappeared from the surface, use a steel trowel to give a smooth finish. The most important single factor in producing a satisfactory surface by troweling is the time of the final finishing. The concrete should be allowed to stand for several hours after it has been laid, until the surface is quite stiff and workable, but not set. The steel trowel is used to compact and produce a dense surface, rather than just to smooth out the rough spots. For this reason the weight of the body must be behind each stroke of the trowel as it compacts and smooths in a single motion. Excessive

troweling will remove too much moisture from the mass, and cause the formation of numerous fine cracks called hair checks, as well as excessive dusting, when the work dries out. If a rough finish is desired, the concrete may be covered with burlap or canvas belts. A very rough surface can be obtained by "brooming."

The working temperatures for pouring concrete are between 50° and 120° F. If concrete is poured when the temperature is just above freezing, the concrete is very slow in setting, and there is danger that the forms will be removed too early. If the concrete has begun to set when the temperature goes below freezing, the water trapped in the concrete will freeze and break the bonds already formed, causing the concrete to crumble. If the temperature is below freezing when the concrete is poured, it will not set until the water has thawed.

PLACING CONCRETE

When the actual pouring starts, the placing operations should be continuous until a definite section is completed. You should always keep the surface of fresh concrete about horizontal while filling wall, column, and footing forms. This is achieved by using inclined chutes and tremies, so that each batch is deposited into position without a free fall greater than 5 feet, and without the necessity of moving it horizontally in the forms. As each batch of concrete is placed in the forms, it should be consolidated and worked into all corners and around the steel by hand-spading or by vibrators. Excellent consolidation of concrete is achieved by the use of vibrators, but judgment and care should be taken so that the concrete is not overworked, and to see that the steel extending into concrete undergoing set is not vibrated. Construction joints should be located according to plans. If other construction joints are needed, they should be located to avoid imparing the strength of the structure. As sidewalls are constructed, if reinforcing steel does not

extend across the horizontal joint, provision should be made, before the concrete sets, for keying later work to the sidewall. Keying two joints together is generally achieved by embedding a beveled key form, as shown in figure 10–7. The stop-board with the beveled key form (illustrated in figure 10–7) is also used in case of heavy rain when you desire to key off and cover the fresh concrete until it has set.

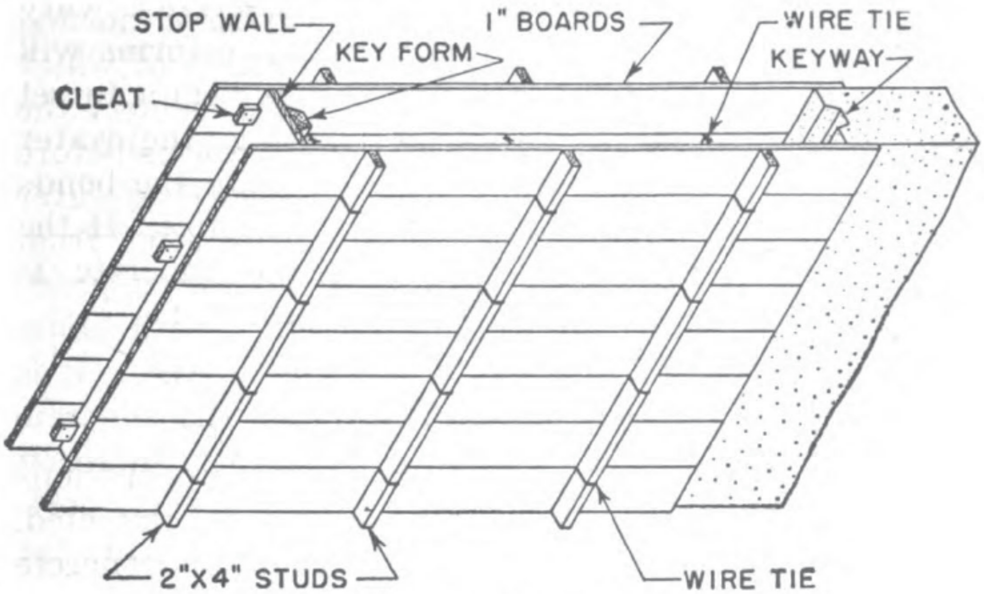


Figure 10–7.—Vertical construction joint in wall with keyway.

Expansion and contraction joints are provided according to plans, and the distance between these joints varies in construction work, depending upon degree of exposure and temperature variation. In slabs, expansion joints about ¾ of an inch wide, are generally spaced from 50 to 150 feet apart. All such joints should be filled with a bituminous material to make them watertight. In JOINING and BONDING fresh concrete to concrete that has hardened, the old surface should be roughened and cleaned thoroughly by means of wire brooms and water under pressure. Just before placing the new concrete pour, the old concrete should be dampened and a coat of sand-cement mixture about one-half inch in thickness should be applied. This sand-cement mixture is

known as GROUT and should be mixed to the consistency of thick cream.

CURING

The process of keeping concrete damp and at a favorable temperature for a certain length of time to insure complete hardening is called "curing." The quality, strength, and watertightness of concrete depends a great deal on proper curing. The problem of curing in normal temperatures is to prevent a rapid evaporation of water in the concrete. Forms left tightly in place, protect the surface they cover. The practice of wetting forms before placing concrete, prevents the wood from absorbing water from the concrete. Exposed surfaces are protected from drying out for at least seven days by sprinkling or ponding with water, or by covering the surface with damp sand, earth, straw, or canvas. In freezing weather, it is important to maintain the temperature of the concrete above 50° F. until it has hardened sufficiently to resist freezing. Protection is achieved by canvas covers, portable stoves called salamanders, or steam heat inside the structure. Accelerators, to hasten the hardening process, such as calcium chloride are sometimes used in cold weather with good results. The curing period, during which protection is necessary, is always materially shortened when special concretes that develop a high-early strength are used.

HIGH EARLY-STRENGTH CONCRETES

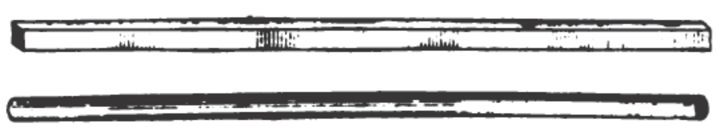
In construction work, where speed of completion is the main factor, and in cold-weather work, quick-hardening concrete is used. The chief high early-strength concretes are produced by means of: (1) high-alumina cement, (2) special high-grade portland cement mixes and (3) the addition of accelerating admixtures. The use of high-early cement is particularly important in military construction. The time of curing is reduced to two days,

which permits early use of the structure. High-early cement is more expensive than standard portland cement and less available commercially, therefore, you'll generally use this type of cement only in times of emergency.

REINFORCED-CONCRETE CONSTRUCTION

Concrete, in which steel is placed in the form of rods, bars, shapes or netting for the purpose of aiding the concrete in carrying loads, is termed "reinforced concrete." Ordinary concrete is about ten times as strong in compression as in tension. Forces which tend to shorten or compress a structural member are called compressive forces, while those forces which cause the elongation or lengthening of a member are called tensile stresses. By adding steel reinforcement in such manner as to resist tension, concrete becomes available for structures which otherwise could not be made of concrete material. Steel bars and rods for reinforcing concrete may be either deformed or plain. Deformed bars are

Figure 10–8.—The twisted bar.



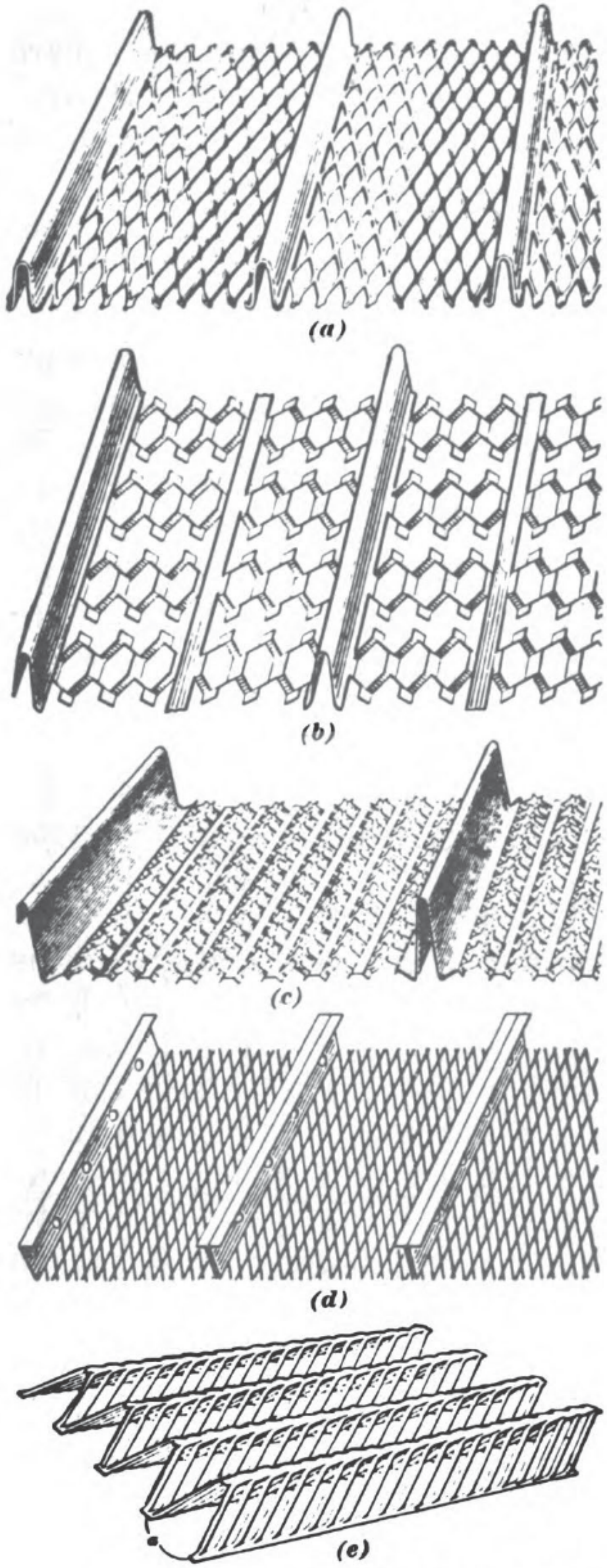
Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–9.—Plain bars.

used more frequently as they provide a stronger bond with the concrete. There are many types of deformed bars; a typical one, the twisted bar, is shown in figure 10–8.

Plain bars are usually either round or square in cross section, as indicated in figure 10–9. These bars are made of soft steel and are easily bent. These steel bars should be thoroughly cleaned before being placed in order to obtain a positive adhesion to the steel. Some of the reinforcing steel may profitably be assembled before it is placed in the forms. In many cases the bars and stirrups used for reinforcement in a beam may be wired together in a frame. Then you'll simply have to line and level them in the forms, place braces where necessary, and make end connections with adjacent frames. Wall reinforcement should be made up into frames, the same as for beams and girders. In some cases, it may be best to assemble even slab reinforcement on the ground and place it in assembled units. All reinforcing metal should be placed in the forms and securely fastened in correct position by wiring before the placing of concrete. Slab and wall bars should be tied at their intersections in order to keep them from slipping out of place. Particular attention should be given to loose-bar reinforcement to see that it is accurately and properly supported in position and that it is not disturbed until the concrete is poured. After the reinforcing steel is all in place, it should be carefully inspected to see that all bars are in their correct places and fastened so they will not be displaced during the pouring.

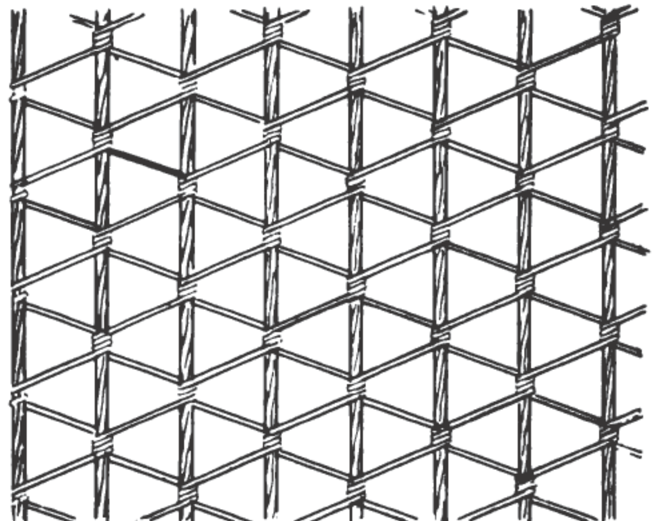
The form of reinforcements, known as expanded metal, is used mainly for reinforcing slabs. Various types of expanded metal are illustrated in figure 10–10. Three types of expanded metal formed with V-ribs are indicated in (a), (b), and (c). In view (d) is shown a type formed with T-ribs. The expanded metal shown in view (e) is called "*trussit*" which is used to support a thin roof slab of concrete without other support and is frequently used in the construction of light partitions without studding. The reinforcement known as WIRE FABRIC, is made by weaving or welding wires or rods together to form rec-



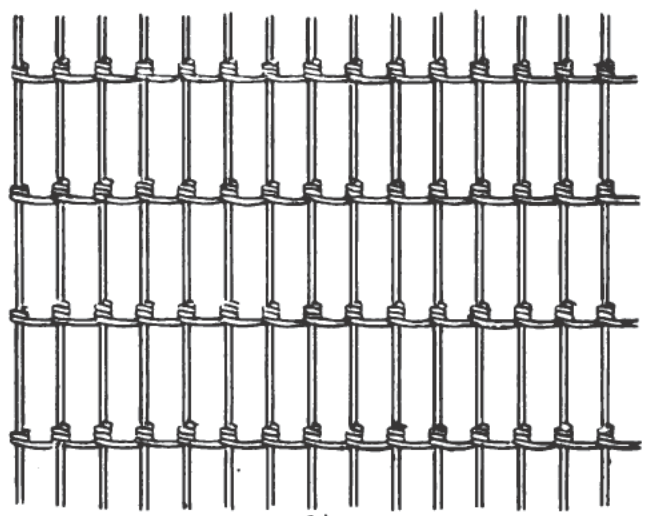
Courtesy of International Textbook Co., Scranton, Pa

Figure 10–10.—Types of expanded metal.

tangular or triangular shaped meshes. Two types of woven-wire fabrics are shown in figure 10–11. The type shown in view (a) is the triangular mesh, and that in view (b) is the rectangular mesh.



(a)



(b)

Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–11.—Types of wire fabrics.

STIRRUP is a term given a piece of steel used to hold other steel in place. This stirrup may be used in flat slabs to raise the steel off the deck. Frequently this type of stirrup is called a CLIP or chair. Stirrups are also used to hold reinforcing bars in columns or beams in a uniform relation to each other and a uniform distance from the

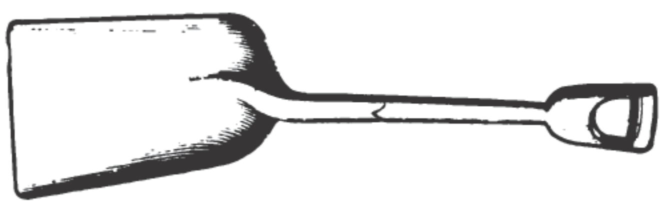
form sides. "Structural shape" is the term applied to a number of bars that are held in place by means of stirrups.

Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–12.—A square-pointed shovel.

Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–13.—A mortar hoe.



Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–14.—A scoop shovel.

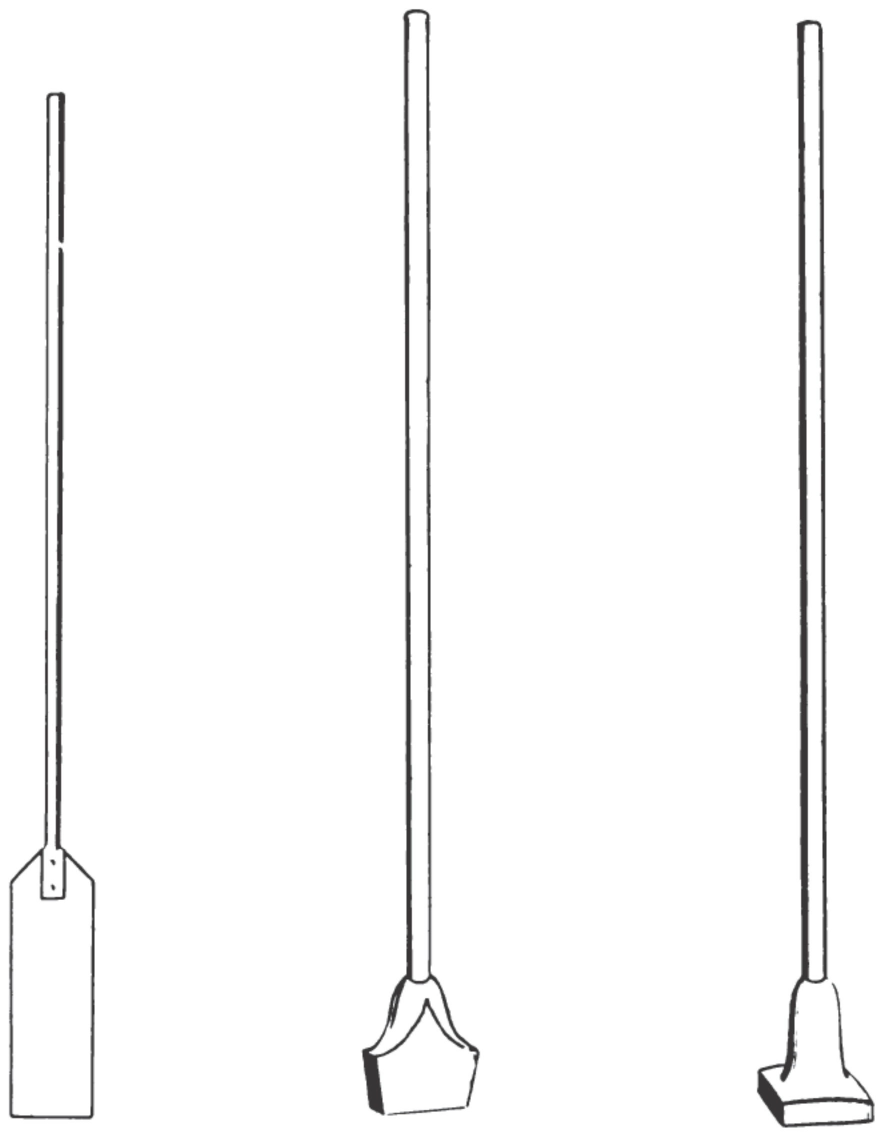
CONCRETE TOOLS AND EQUIPMENT

Extensive use of shovels is made in handling both aggregates and concrete. A square-pointed shovel, shown in figure 10–12, is used for shoveling sand and stone, and also for mixing concrete by hand. However, when concrete is to be mixed by hand, the work may be facilitated by using a heavy rake or a mortar hoe, shown in figure 10–13.

The scoop shovel (figure 10–14) should be used to load wet concrete into carts or wheelbarrows. This shovel,

as you'll notice, has a deep bowl that retains the concrete. Most of the liquid would be lost if you used square-pointed shovels in handling concrete.

Spading tools of various kinds are used to compact wet concrete. The spade used for plain concrete and

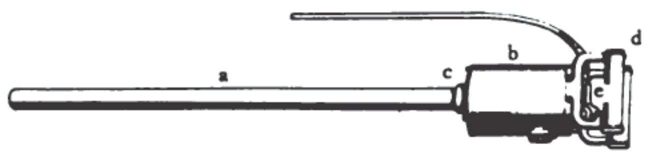


(a) (b) (c)

Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–15.—(a) Compacting tool for work around steel reinforcements.
(b) A rammer used for confined places.
(c) A rammer used for flat surfaces.

for open places in general, can be made by flattening out a garden spade. Nearly all of the air voids can be removed by ramming the concrete with the end of the spade. In order to obtain a smooth surface on the face of a wall, you simply run the blade vertically down next to the form faces, then pull the handle toward you. In this manner, you draw the stone or gravel away from the face and permit the mortar to flow in next to the form. The tool shown in figure 10–15(a), consists simply of a piece



Courtesy of International Textbook Co., Scranton, Pa.

Figure 10–16.—A mechanical vibrator.

of sheet steel fastened to a round iron bar. This smaller tool is used to work concrete around reinforcing metal to ensure a thorough bond with the reinforcement and at the same time to prevent displacing the reinforcement during the spading operation. In order to consolidate dry mixtures, rammers or tampers, similar to those shown in figures 10–15(b) and 10–15(c), are used. The one shown in figure 10–15(b) is suitable for tamping concrete in small or confined places. The rammer shown in figure 10–15(c) is commonly used for compacting such work as decks and other flat surfaces.

Another tool that is used for compacting dry mixtures is the mechanical vibrator, one type of which is shown in figure 10–16. The vibrator tube *a,* which can be inserted into the concrete at various points, contains a rotating shaft that is mounted off center sufficiently to produce a vibrating motion. This shaft is attached to the electric motor *b* by means of a flexible connection *c.* The tool is held by hand grips *d,* in one of which is a trigger switch *e* for starting and stopping the motor.

SAFETY PRECAUTIONS IN CONCRETE OPERATIONS

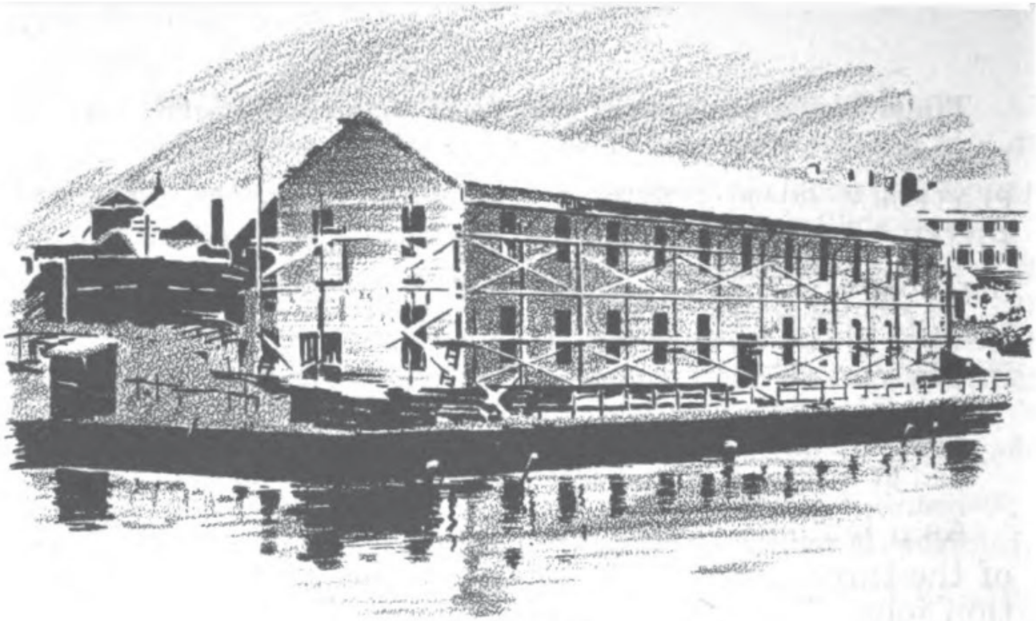
In the handling of materials for concrete construction, cement burns are common, therefore, you should have a good remedy available. Equal proportions of lanolin (a wool fat or grease) and vaseline, make an excellent healing ointment. Linseed oil is also frequently used on cement burns.

You should always wear gloves when using concrete-working tools, and rubber boots when you find it necessary to walk in wet cement. It is always best to handle cement on the windward side, when you are mixing, in order to avoid the chance of getting fine particles of cement into your eyes. Check the skip cable on the mixer frequently for defects. The concrete mixer must be cleaned daily after use. To clean simply flush the mixer out with water. If it needs additional cleaning, throw in a few shovelfuls of coarse aggregate and roll that in your mixer with clean water. After use, you should always clean concrete tools and equipment immediately so that they may be used efficiently in subsequent operations. Water for drinking purposes should always be stored on the windward side of the mixing platform or machine. In continuous pouring concrete operations, if you drop tools in the mixture as it flows in the chutes or forms, DO NOT, UNDER ANY CIRCUMSTANCES, ENDEAVOR TO RETRIEVE THEM.

QUIZ

1. What is the weight of a bag of cement?
2. Why is it important to avoid exposing cement to excessive heat?
3. How should cement be stored?
4. What is mortar?
5. How are bricks and stone bound together in a wall?
6. Of what does concrete consist?
7. To what is the term aggregate applied?
8. Sand to be used in concrete should be clean and sharp, without any admixture of clay, loam, weeds, or fine dust. Why?

9. When should you use sea water in a concrete mixture?
10. In general, what kind of water will make good concrete?
11. What standard method is used to measure consistency and workability of fresh concrete?
12. How is cement measured?
13. To what does the first number of a concrete mix refer?
14. What are the two methods of mixing concrete?
15. For concrete decks, a standard mixture is 1:2:3½. What does this standard mixture mean?
16. What is the process called by which concrete is kept damp and at a favorable temperature for a certain length of time to insure complete hardening?
17. What is reinforced concrete?



CHAPTER 11

SCAFFOLDING AND STAGING

TYPES OF SCAFFOLDING

Scaffolding and staging are elevated decks constructed so that builders can work on those parts of structures which they can't reach from the ground. In construction, the term SCAFFOLDING applies to a one-story platform, while STAGING is a structure progressively constructed as the erection of a building proceeds. The name "staging" is used because this type of structure is built up in stages, or one story at a time. Scaffolding and staging give you a temporary deck from which you can work, and on which you can place materials and tools that are required for the job at hand. Although these elevated decks are temporary, you must build them carefully. Select good lumber and use lots of nails. Green lumber should not be used because it isn't strong and because it may warp or crack when it dries. You must use strong, dry lumber that is straight grained and free from shakes or knots. GOOD MATERIAL, PROPER NAILING, and GOOD WORKMANSHIP are "musts" in the building of scaffolding and staging in order to ensure the safety of your shipmates and yourself.

There is one essential point that you must always remember—THE ENDS OF ALL SCAFFOLDING AND STAGING PLATFORM BOARDS MUST BE SUPPORTED AND MADE FAST. Pitfalls are formed by unsupported scaffolding and staging boards. When you step on the end of such boards, they'll tip up, and cause you to lose your balance. Serious injury can result from a fall from elevated decks.

SCAFFOLDING

As a builder, you should be familiar with the erection of the three types of scaffolding mainly used in construction jobs. They are:

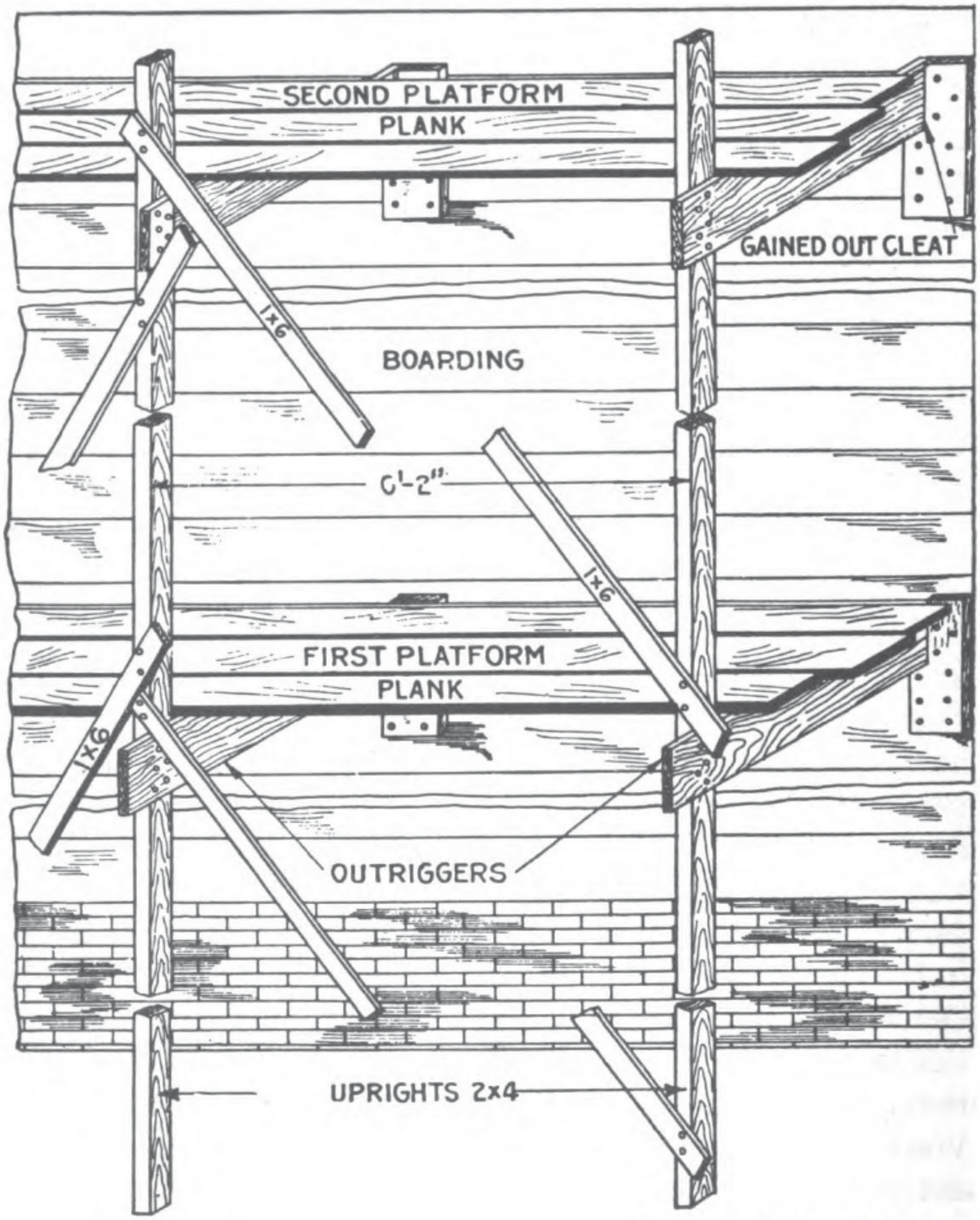
1. Two-platform scaffold.
2. Framed portable-supported scaffold.
3. Portable scaffold.

Swinging stages supported by lines may also be used but they present more of a problem of rigging than of building. The rigging assemblies used in this method of scaffolding are discussed in chapter 17, Rigging and Assemblies.

TWO-PLATFORM SCAFFOLD

A simple form of a typical two-platform scaffold is shown in figure 11–1. A careful study of this scaffold shows you that it consists of uprights, outriggers, cleats, and planks to form a platform. You'll generally use this type when constructing wooden buildings. Outriggers, or supports, of 2 x 6's or 2 x 8's, are nailed to the cleats and uprights in order to support the deck planking. Referring to figure 11–1, you'll notice that notches are made in the cleats in which the outriggers are made fast. Cleats should be so placed that they will fit over a stud for sound nailing. It is only necessary for you to use cleats when there is no window or door opening in the bulk head. Where you have openings in the wall against which you are erecting a scaffold, you may nail the outrigger to the studding to brace it. You should use 2 x 4's for the uprights, and 1 x 6's or 1 x 8's for the diagonal brackets,

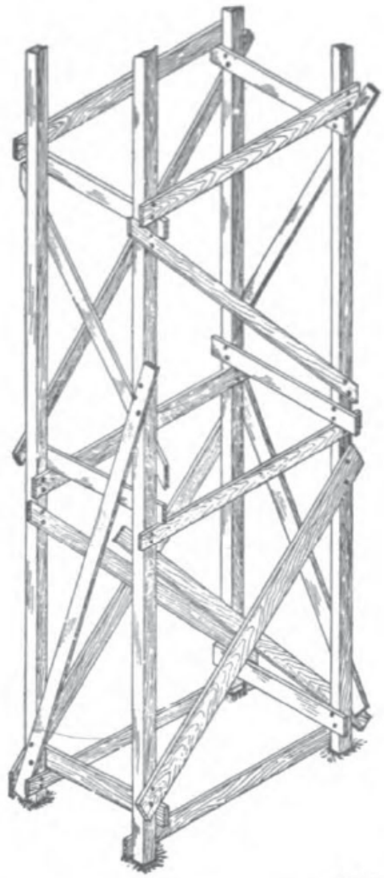
as indicated in figure 11–1. You'll notice also that 1″ x 2″ strippings are cross-braced from the building to the uprights in order to prevent lateral movement. You'll find that only occasional cross-bracing is necessary. Never use less than 2″ x 10″ or 2″ x 12″ material for planking in order to ensure a safely supported elevated platform.



Courtesy of Theo. Audel & Co.

Figure 11–1.—A typical platform scaffold.

The distance from support to support is determined by the thickness or strength of planks that are used in the erection of a scaffold. For this type of scaffolding, when you use 2″ x 10″ or 2″ x 12″ planking, the distance between supports may safely be 8 to 10 feet for ordinary working purposes. Be sure to make fast all planking to the horizontal outriggers.



Courtesy of Theo. Audel & Co.

Figure 11–2.—Detail of a framed portable scaffold.

FRAMED PORTABLE-SUPPORTED SCAFFOLD

A scaffolding which is used in the renovation and installation of high ceilings is shown in figure 11–2. This type of scaffold is self-supporting and can be easily moved as the occasion demands. The construction of this form of scaffolding consists of four uprights, and cross and diagonal braces. (See figure 11–2.) An excellent scaffold

can be constructed to provide three elevated platforms in order to expedite the erection of 40′ x 100′ Quonset huts or similar prefabricated buildings. Figure 11–3 illustrates this type of scaffolding. You'll notice that this

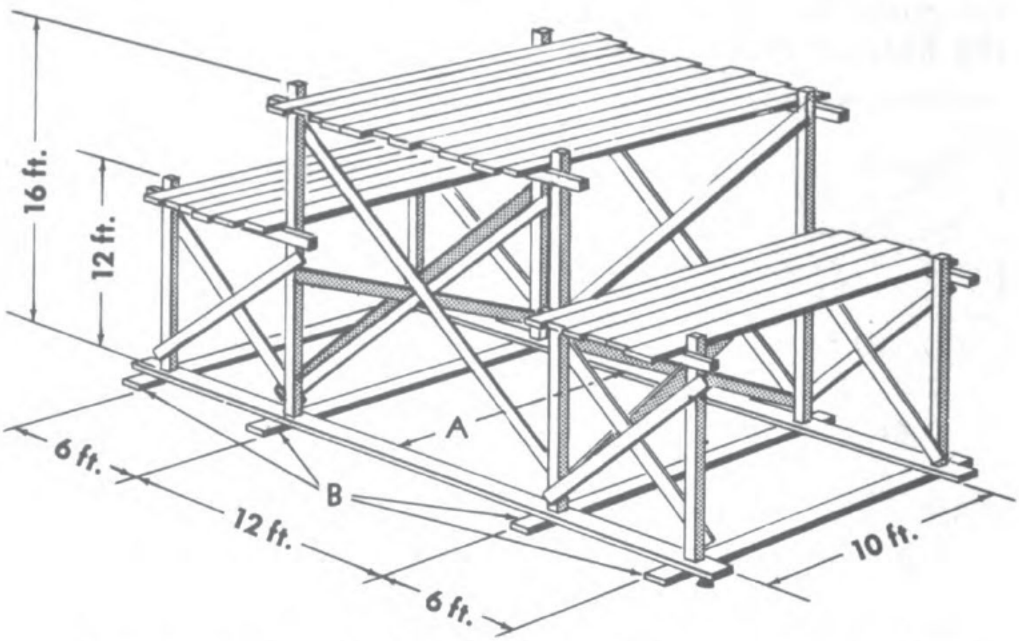


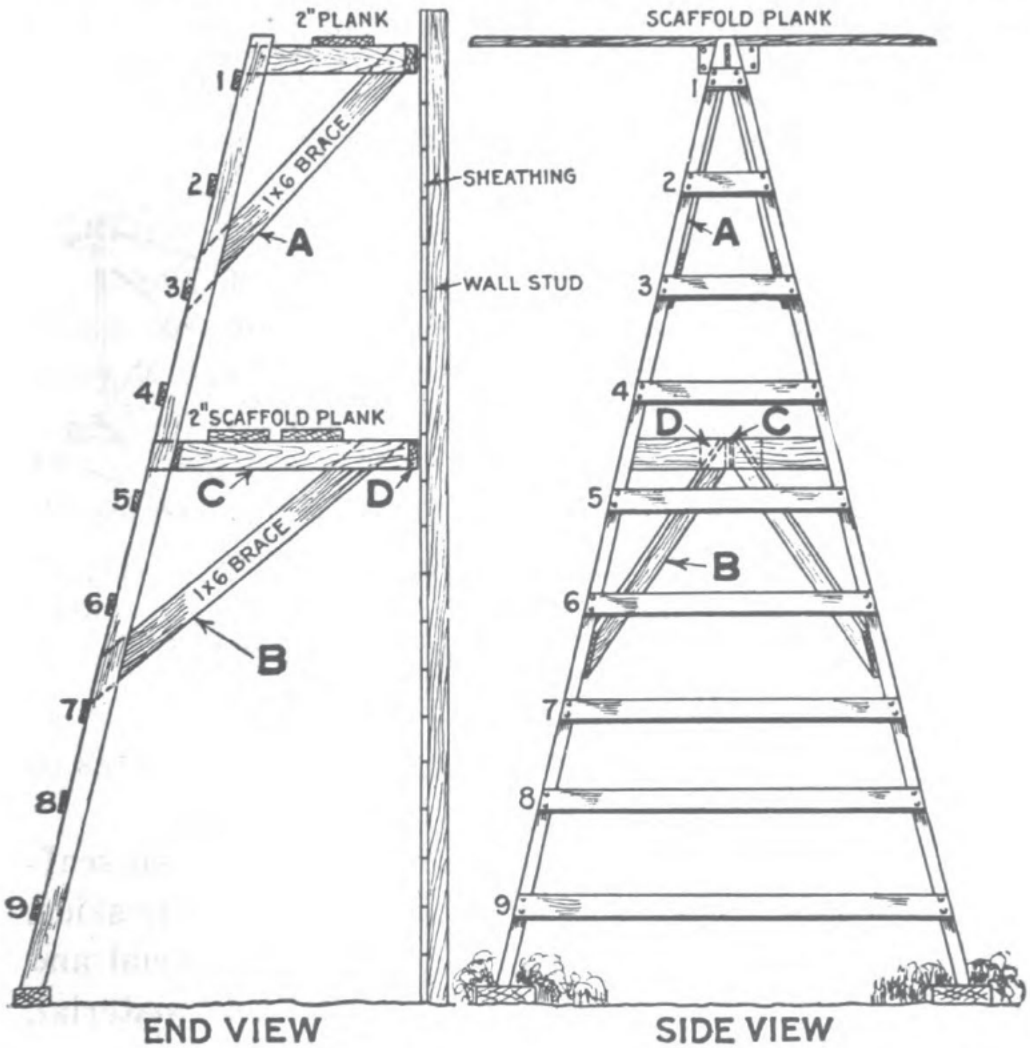
Figure 11–3.—Typical scaffold for the rib-construction of a 40′ x 100′ Quonset hut.

scaffolding is made by adding two platform structures to the framed portable scaffold shown in figure 11–2.

In order to make the framed portable-supported scaffold, a rectangular frame is constructed with four skids, 12 feet long. Make the skids of 2″ x 8″ material and fasten them to two foundation pieces of 2″ x 6″ material, 24 feet in length. The four skids, indicated in figure 11–3 as *B*, are fastened to the foundation pieces *A* in such a manner as to have their ends extend 1 foot on each side of the foundation pieces. This increases the stability of the scaffolding. The two center skids are spaced 12 feet apart, and the two end skids, 6 feet from the center skids.

Four 4″ x 4″ uprights, with diagonal cross braces, are

then nailed to the foundation pieces at their intersection with the center skids. These uprights should be 16 feet long. To make these uprights even more secure, use 90-degree angle irons and lag screws to fasten them to the foundation. The diagonal braces should be of 1″ x 4″ or 1″ x 6″ material. Four outriggers or supports are secured



Courtesy of Theo. Audel & Co.

Figure 11–4.—A portable scaffold for sheathing and siding frame buildings. (a) End view. (b) Side view.

to the uprights to which planking of 2″ x 12″ material is made fast to form the horizontal elevated deck.

Four 4″ x 4″ uprights with diagonal braces are then nailed to the foundation pieces at their intersection with

the end skids. These uprights should be cut 12 feet in length and made secure by fastening them to the foundation pieces with 90-degree angle irons and lag screws. The diagonal braces should be of 1″ x 4″ or 1″ x 6″ material. The two end platforms are constructed in the same manner as the center platform. All planking must be securely nailed to the horizontal outriggers or supports.

PORTABLE SCAFFOLD

A portable scaffold frequently used when installing sheathing and siding on frame buildings is shown in figure 11–4, which illustrates the end and side views, and shows you the method of constructing this type of scaffolding. You'll notice that A and B are struts of 1″ x 6″ material which support the platform beam C to which the 2″ scaffold planks are made fast. The end piece is illustrated by D. This type of portable scaffold affords an excellent and handy means of providing elevated decks for the installation of the corrugated iron sheets on Quonset huts and similar prefabricated structures.

USING SAW HORSES FOR SCAFFOLDING

In chapter 6, the construction of saw horses was discussed and illustrated in figure 6–17. These horses or trestles are constructed to support work 2 feet from the deck, for marking or sawing. Simply making two saw horses of more substantial material, with the cross beams at the desired height above the deck, will provide supports on which 2″ planks can be laid. By using saw horses you can make excellent scaffolding for use in the erection of Quonset huts, small prefabricated structures, or small wooden buildings.

STEEL AND ALUMINUM SCAFFOLDING

Special steel and aluminum scaffolding is used to speed up construction and maintenance operations. For interior work and erection, there are two basic types. Figure 11–5 shows the scaffolding used for the Quonset 20. Figure 11–6 shows the scaffolding used for the Quonset 40. Figure 11–7 shows this scaffolding in use during the actual construction of a Quonset 40. These scaffolds can be disassembled and transported whenever necessary. They are mounted on steel casters, with brakes and adjustable supports, which permit quick movement and positioning of each tower. This scaffolding is equipped with special, trussed planks, 12 feet long, which are so placed as to enable workmen to be within comfortable and safe-working distance of all building connections.

For exterior work, there is an aluminum and steel scaffolding designed to facilitate construction operations. Figure 11–8 illustrates this type of scaffolding. It is

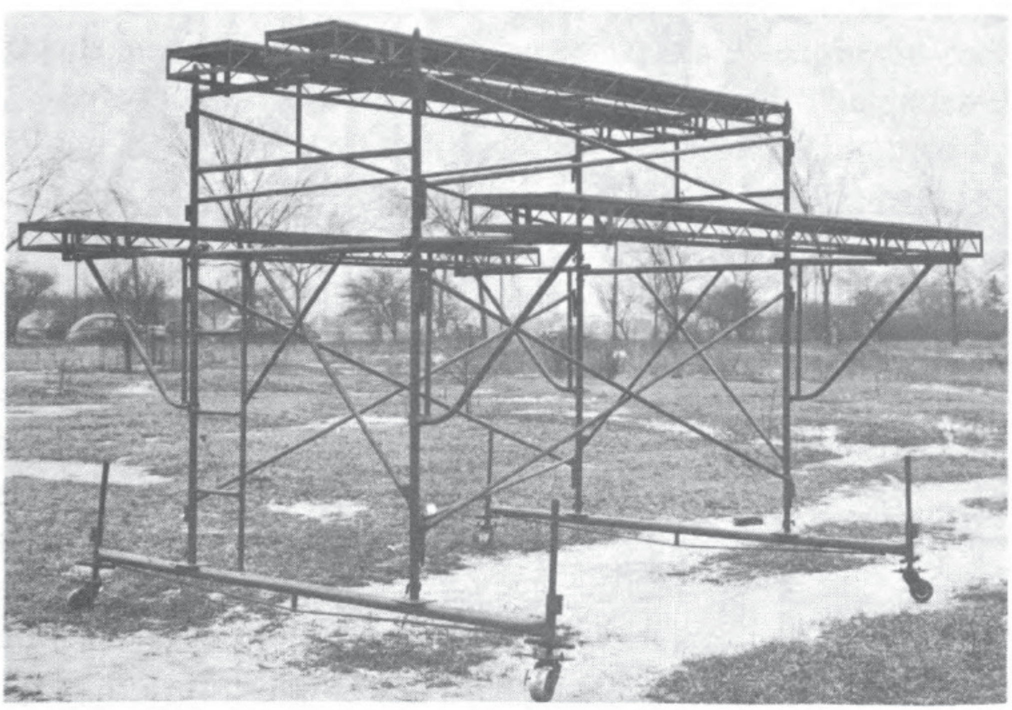


Figure 11–5.—The scaffolding for interior Quonset 20 construction.

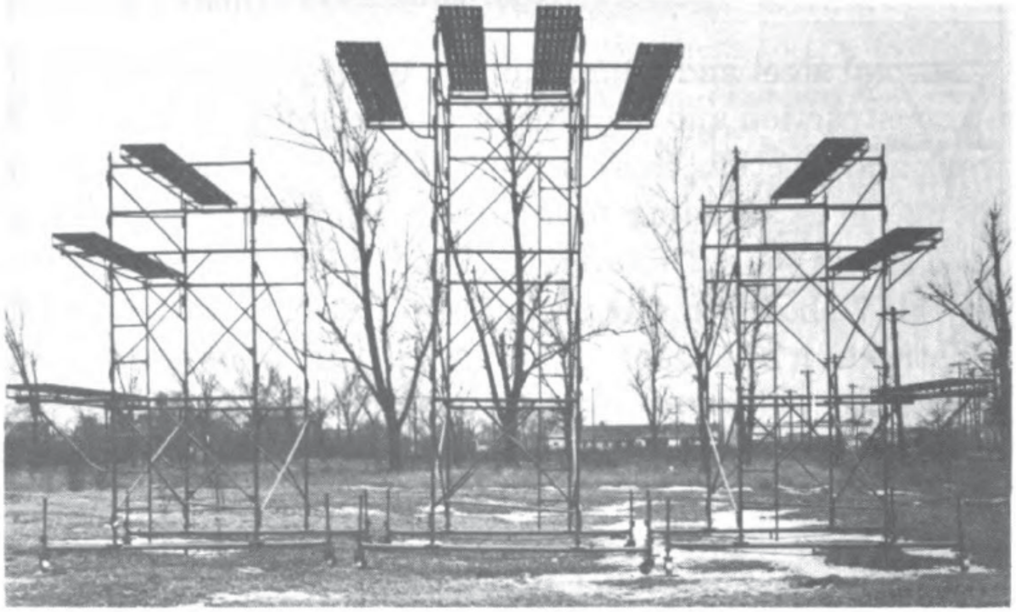


Figure 11-6.—The scaffolding for interior Quonset 40 construction.

Figure 11-7.—Actual construction of Quonset 40 with scaffolding.

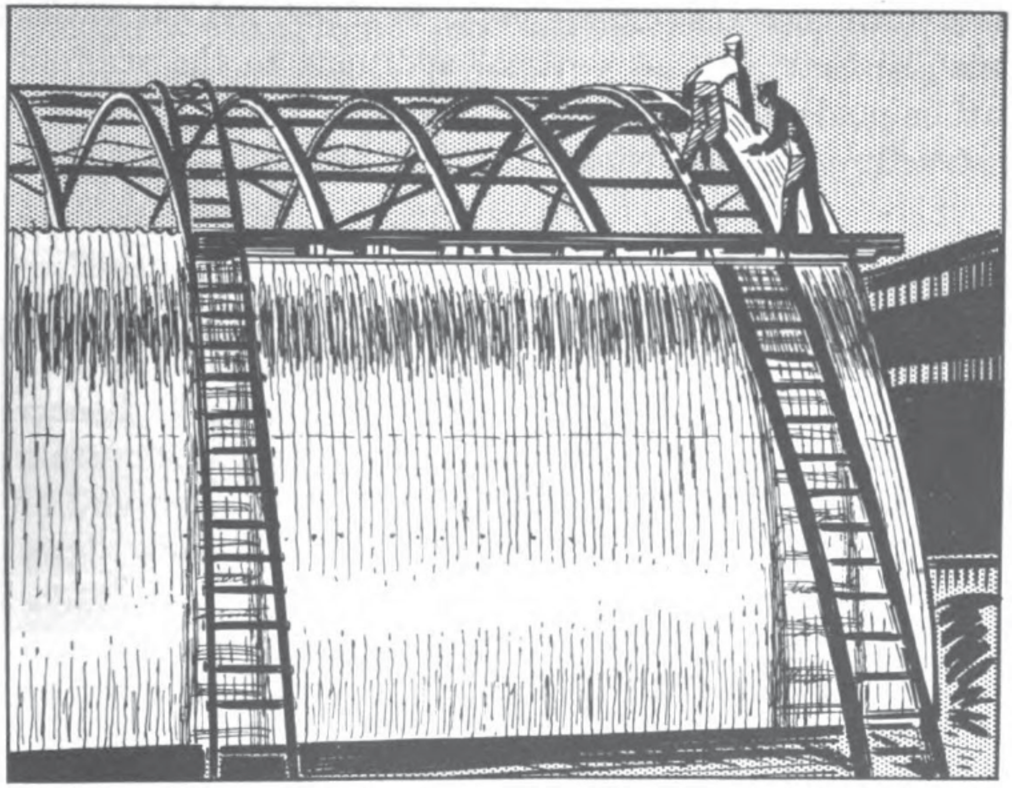


Figure 11-8.—Aluminum exterior scaffolding.

light in weight and can be easily transported to other locations. Each ladder consists of one straight 10-foot section, and three curved 7-foot sections. The trussed plank is 20 feet long and is light enough to be handled by 2 men. Adjustable ladder brackets locate and support the plank at any position and angle on the roof curve. The steel tubular scaffolding (figure 11–9) is equipped with a pneumatic-tired wheel, with locking bolt. Platforms mounted on adjustable ladder brackets are used with this scaffolding. Two of these ladders may be used in conjunction with a 20-foot, reinforced, wooden plank, and 2 plain, adjustable, ladder brackets.

STAGING

In building tall structures, you can readily see that some type of elevated platform heavier and stronger

than ordinary scaffolding must be used. A structure must be built so that vertical additions to the scaffold can be made as the building rises story by story. Such a structure is called "staging." You probably won't need

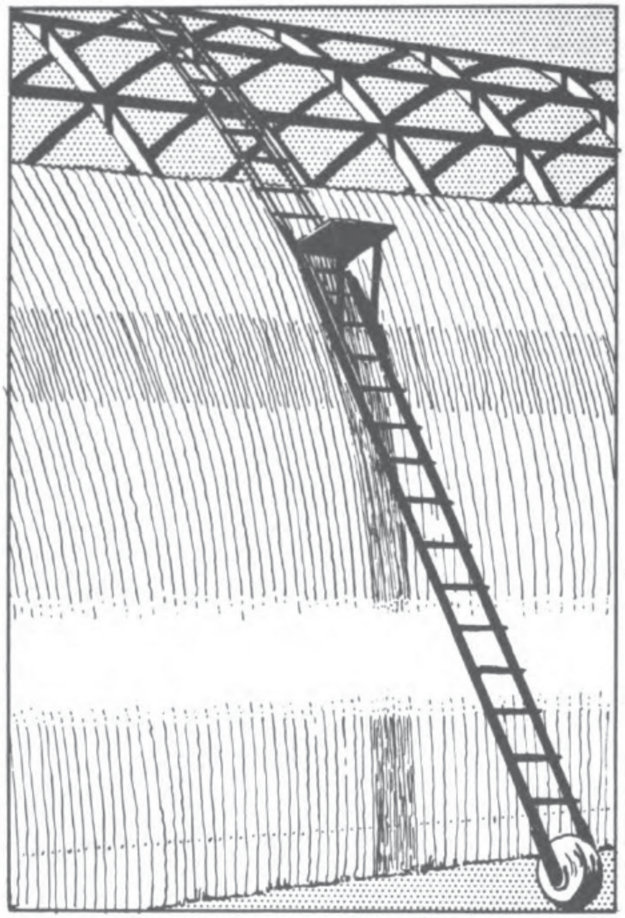


Figure 11-9.—Steel scaffoldings with pneumatic tires for exterior work.

staging in your work, as most prefabricated structures and buildings erected by the Seabees are not over 20 feet in height.

SAFETY PRECAUTIONS

The two chief causes of accidents are carelessness on the part of the workmen and unsafe working conditions.

Unsafe working conditions can be remedied, but eliminating carelessness is a matter of constant training and supervision.

Some typically hazardous practices among Builders are: (1) working on staging which does not have a back rail, and (2) working where tools or materials are scattered carelessly on elevated decks. Under such conditions, accidents are bound to happen. So, the first step is to remedy the conditions. Clean up the decks or working platforms.

You can get into trouble by "doping off." The "wise guy" who takes unnecessary risks on a ladder or anywhere else around construction is a hazard not only to himself but to everyone else. Don't drop or throw anything—there'll be plenty of falling objects to look out for that are dropped accidentally.

When you're on scaffolding, you're up in the air. Loose, flapping clothing will catch on the scaffolding and throw you off balance. This is particularly true of loose sleeves and turned-up trousers.

You don't have to be a steeplejack to be a good Builder. You're probably safer when you are working high than when you are on the deck IF YOU OBSERVE ALL SAFETY PRECAUTIONS, but mighty few "dare-devils" retire on twenty.

QUIZ

1. What are the three "musts" in the building of scaffolding and staging?
2. What are the three types of scaffolding mainly used in construction jobs?
3. What are the two typically hazardous practices among Builders in respect to scaffolding?

4. Why shouldn't green lumber be used in the building of scaffolding?
5. What is the one essential point that you must always remember in the building of scaffolding?
6. For what is a framed portable-supported scaffold used?

CHAPTER 12

WOODWORKING

CONSTRUCTING WITH WOOD

You can't build anything from wood unless you know the methods used to join pieces of timber. The number of different kinds of connections is really very small and the principles upon which they are based may be mastered very quickly.

A knowledge of woodworking cuts and joints also enables you to make such items as index boxes, bulletin boards, filing cabinets, storage shelves, and shipping boxes and crates. Your stateside and most overseas naval

bases usually have a shop equipped with the necessary hand tools as well as three or more standard woodworking machines.

STANDARD CUTS IN WOOD

Most lumber is either rough-sawed or dressed so that it has a rectangular cross-section. However, some pieces may be further shaped or milled before they are supplied to the user. Examples include moldings, such as the reverse ogee or quarterround, baseboards, boat fender stock, and tongue-and-groove flooring. (See figure 12–1.)

If pieces of lumber of the desired shape or size cannot be obtained, it's up to you to shape them. You may use

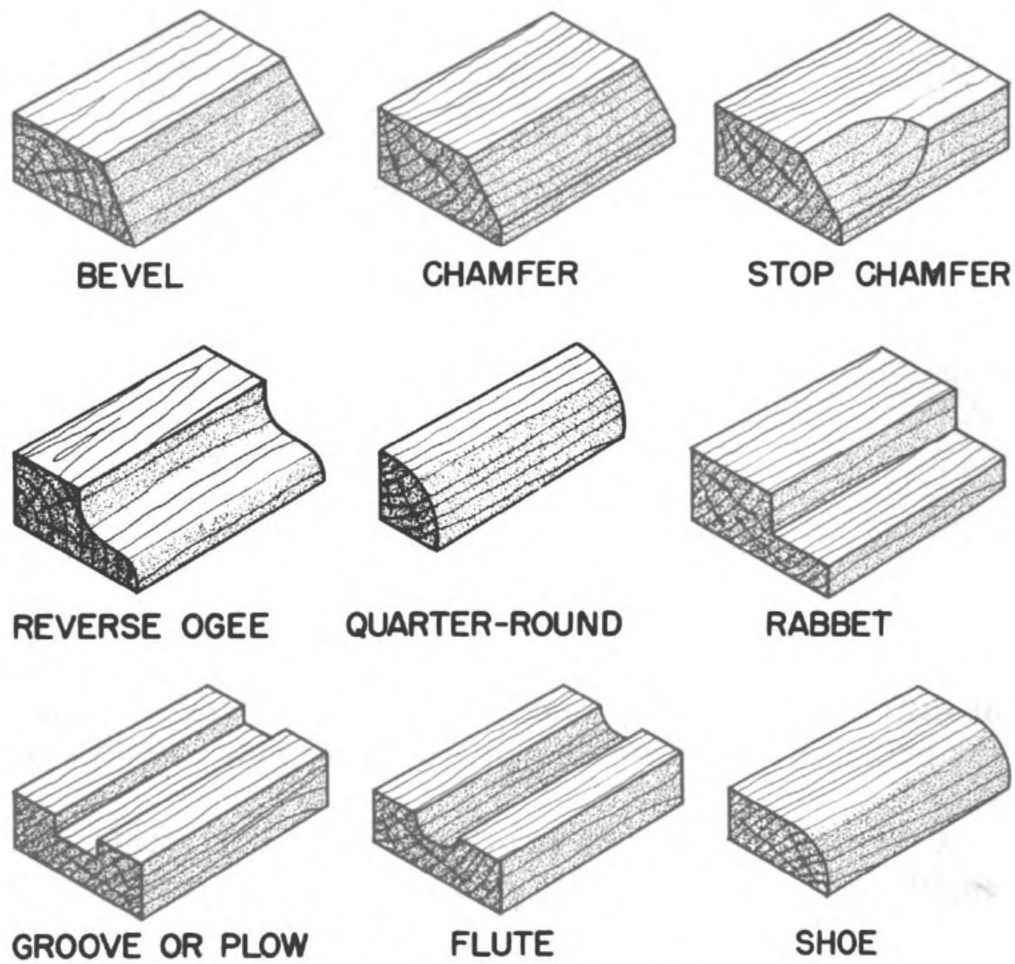


Figure 12–1.—Standard cuts in wood.

hand tools or power machines, depending upon your experience and the available equipment.

EDGE JOINTS

There are four standard methods of joining boards edge-to-edge. (See figure 12–2.) The simplest method is the plain BUTT JOINT in which the surfaces to be joined are squared and then glued together.

The DOWEL JOINT is used for joining pieces to form furniture parts with wide surfaces, such as hardwood table tops and bench tops. The standard dowel for joining pieces $\frac{3}{4}''$ and $1''$ thick is $\frac{3}{8}''$ in diameter and is made of birch or maple.

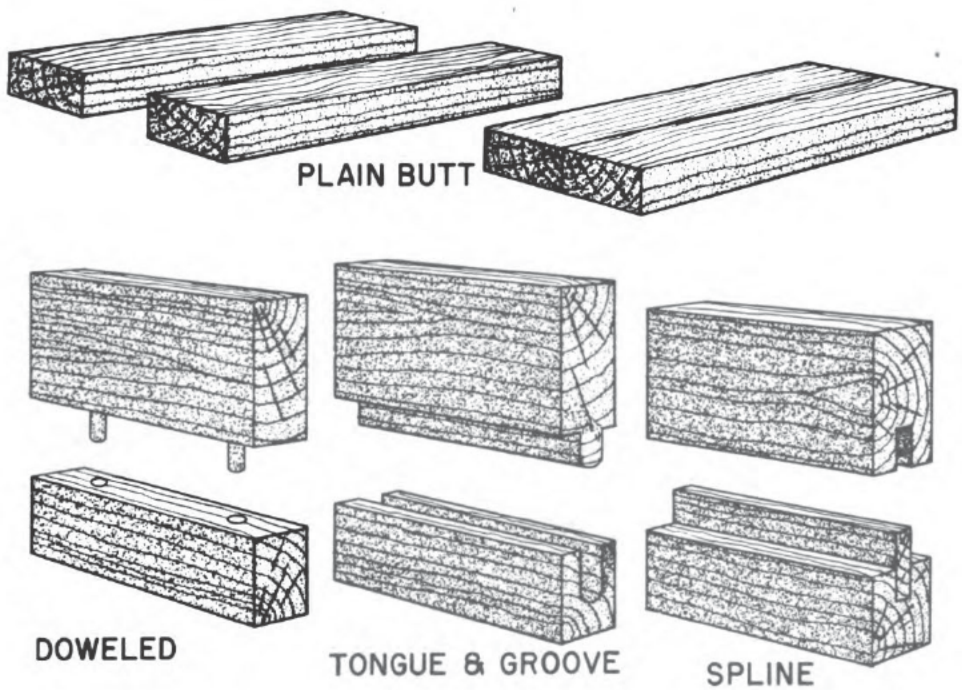


Figure 12–2.—Edge joints.

The most common use of the TONGUE-AND-GROOVE JOINT is for floorings. It's also used for ceilings and closet linings. This joint is seldom cut in the shop as standard sizes of tongue-and-groove material are available at most lumber yards and supply houses.

The SPLINED EDGE JOINT is seldom used but may be required for some jobs. This joint is strongest when the grain of the spline or strip runs at 90° to the grain of the joined parts.

LAP AND BUTT JOINTS

The plain lap joint is used extensively in all kinds of construction, particularly that which does not require a good appearance. The end half-lap is not as strong as the plain or full lap but it has a better appearance and requires less space. The corner half-lap is used for framing of buildings, boxes and cabinets, and many other types of construction. (See figure 12–3.)

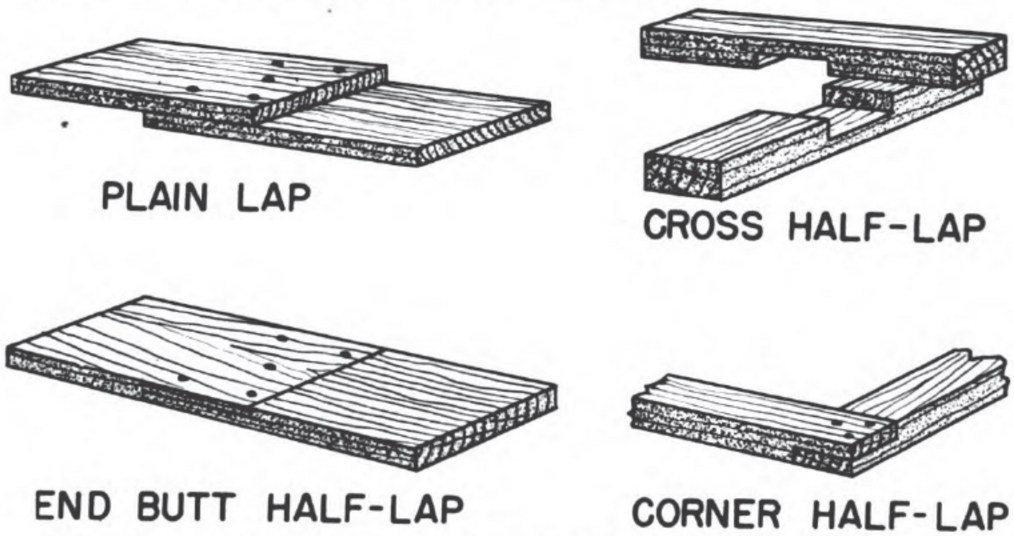


Figure 12–3.—Lap joints.

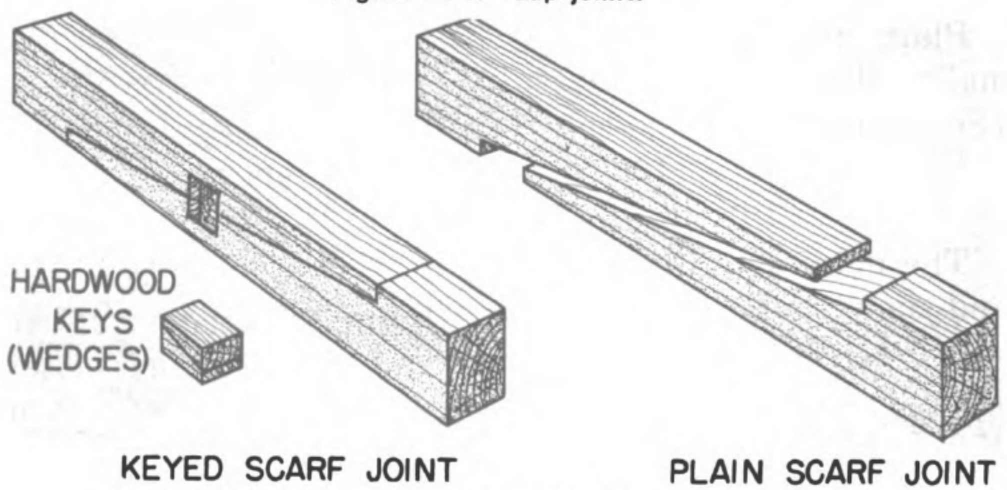


Figure 12–4.—Typical scarf joints.

The scarf joint is a special type of lap joint that is used for jointing heavy timbers. Figure 12–4 illustrates typical scarf joints.

The end butt joint with fishplates is used for joining short members to make long pieces. It has a disadvantage of being bulky. Fishplates may be secured with nails, screws, or bolts. (See figure 12–5.)

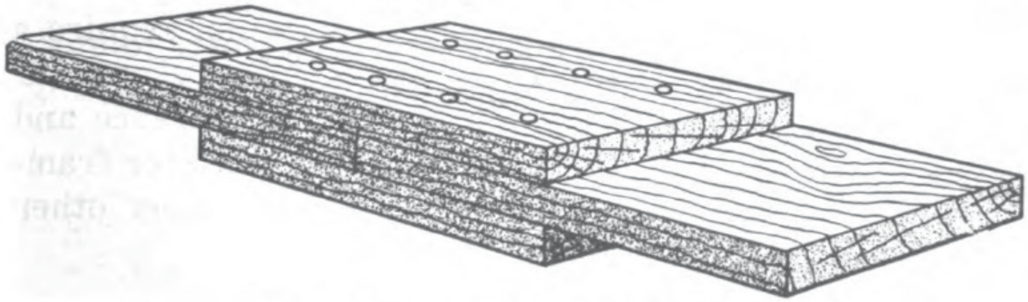


Figure 12–5.—End butt with fishplates.

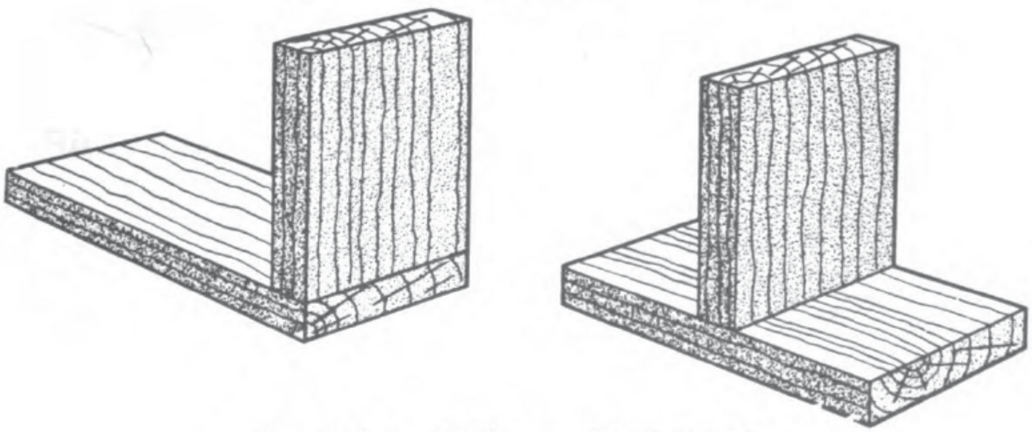


Figure 12–6.—90-degree plain butt joints.

Plain butt joints (90°) are the easiest of all joints to make. They are usually nailed or fastened with screws. (See figure 12–6.)

DADO, GAIN AND RABBET JOINTS

The plain dado joint is often used in making cabinets and shelves. It is usually cut with a dado head (cutter) which fits the mandrel of a circular power saw. You may also make this cut by hand with a backsaw or tenon saw and finish it with chisels. This joint may be glued, nailed, or fastened with screws. (See figure 7–1.)

The gain joint is a special kind of dado which is used when appearance is an important factor. You may use a gain joint in the same way as you would the plain dado. Dadoes and gains are both cut across the grain of the wood.

Rabbet joints are often used in conjunction with dadoes. They may be cut either across the grain or with the grain. (See figure 7–2.) Rabbets may be made with the circular saw dado head, or blade, or with a power jointer. They may also be cut by hand with special rabbeting planes.

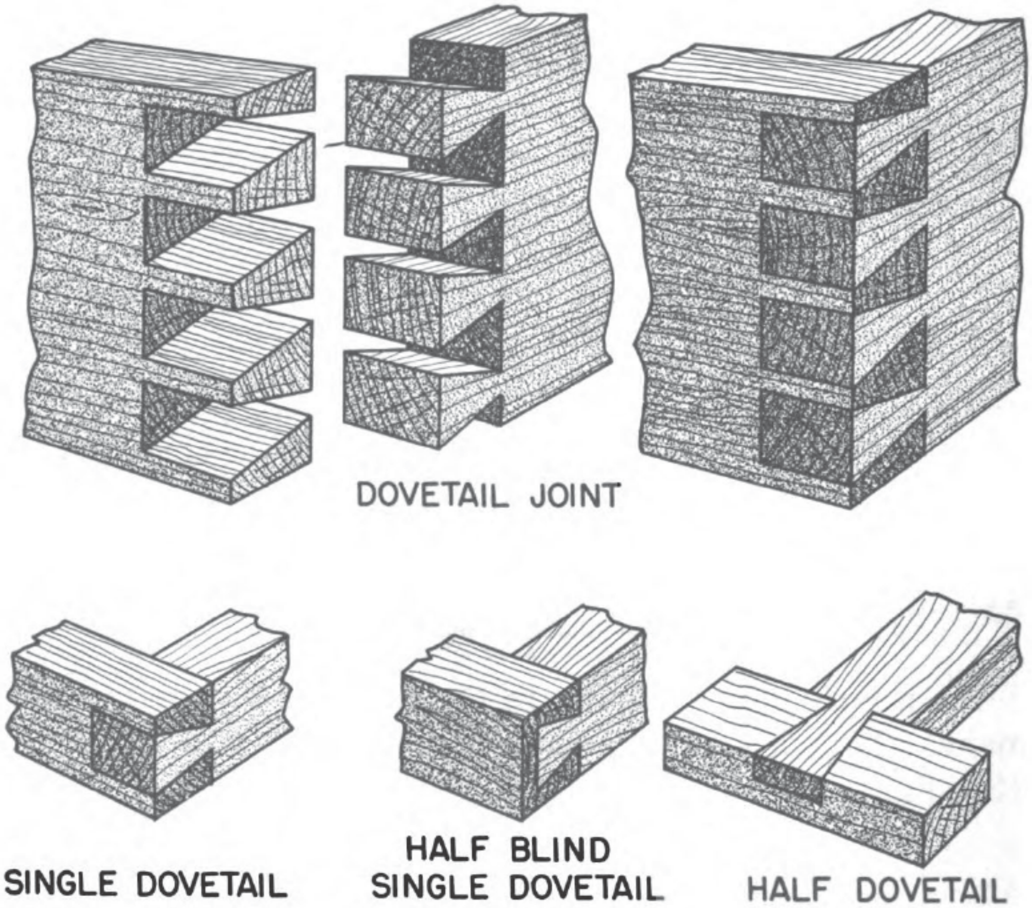


Figure 12–7.–Dovetails.

DOVETAILS

One of the favorite joints of cabinetmakers and other skilled wood craftsmen is the dovetail. It's used mostly on the corners of furniture drawers and in making chests.

The locking features of the dovetail makes it an excellent joint for the corners of desk drawers or similar construction. Such joints are usually made with blind dovetails, so that the joints are not visible from the outside of the furniture.

Single dovetails and half dovetails are used for heavier construction where locking joints are required. (See figure 12–7.)

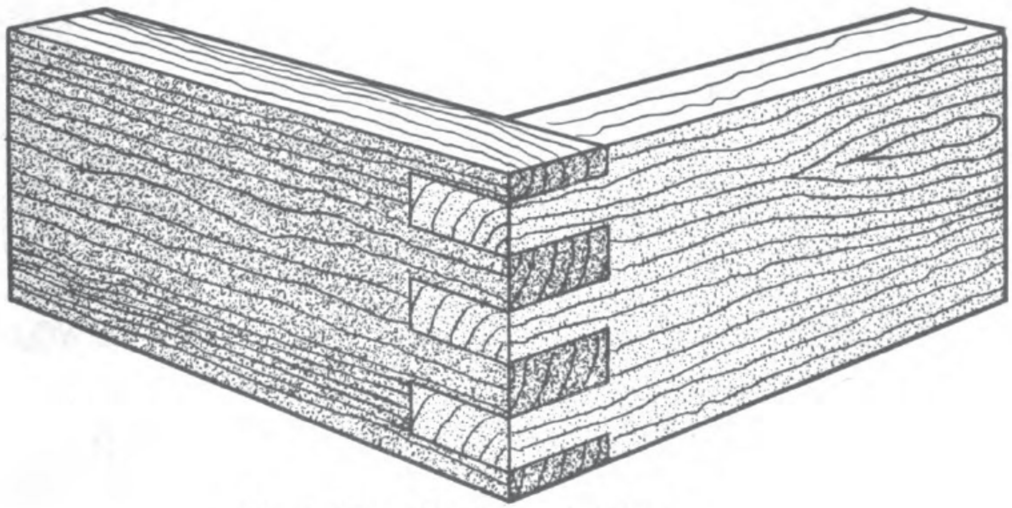


Figure 12–8.—The box corner joint.

Dovetails must be laid out with exceptional accuracy. Use a sharp knife edge or scratch awl for marking and a T-bevel for laying out the angles. You may saw them out with either a backsaw or a tenon saw and finish the work with chisels.

BOX CORNER JOINT

Many commercial packing boxes and chests are made with the box corner joint. This joint may also be used to advantage in making filing cabinets and boxes. You may cut it on a circular saw with the special dado heads. (See figure 12–8.)

MITER JOINTS

The miter joint is used for picture frames, boxes, screen doors, panel frames, and other frames. Miter

joints are glued and then fastened with nails, brads, corrugated fasteners, or clamp nails.

The spline miter is an improvement over the plain miter, and it can be cut quickly with a circular saw with a dado head. Other miters require more work and are used only on special jobs. (See figure 12–9.)

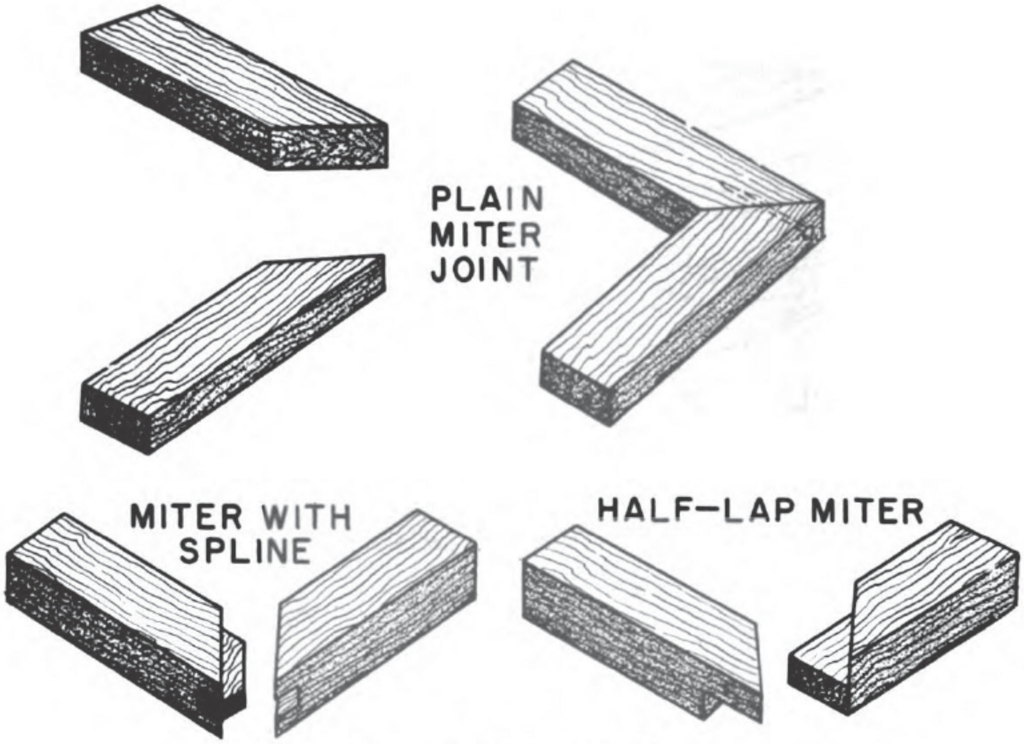


Figure 12–9.—Miter joints.

MORTISE AND TENON

Good furniture usually is made with a number of mortise and tenon joints. (See figure 7–4.) This joint is assembled with glue and is much stronger than it appears to be. It can be wedged, split, or offset. You can't go wrong with mortise and tenon joints if they are properly designed and accurately fitted. The slip tenon joint may be used the same way as a miter or corner half-lap joint. It should be glued together and can be further secured with dowels, screws, bolts, or nails.

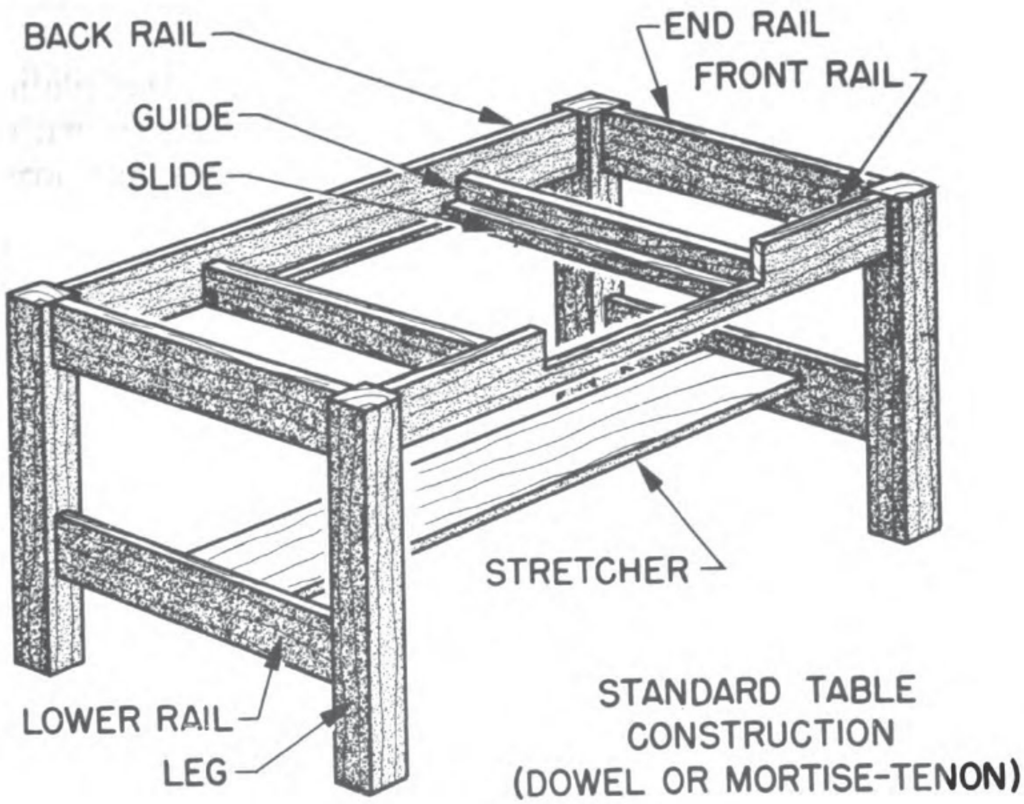


Figure 12–10.—Standard table construction.

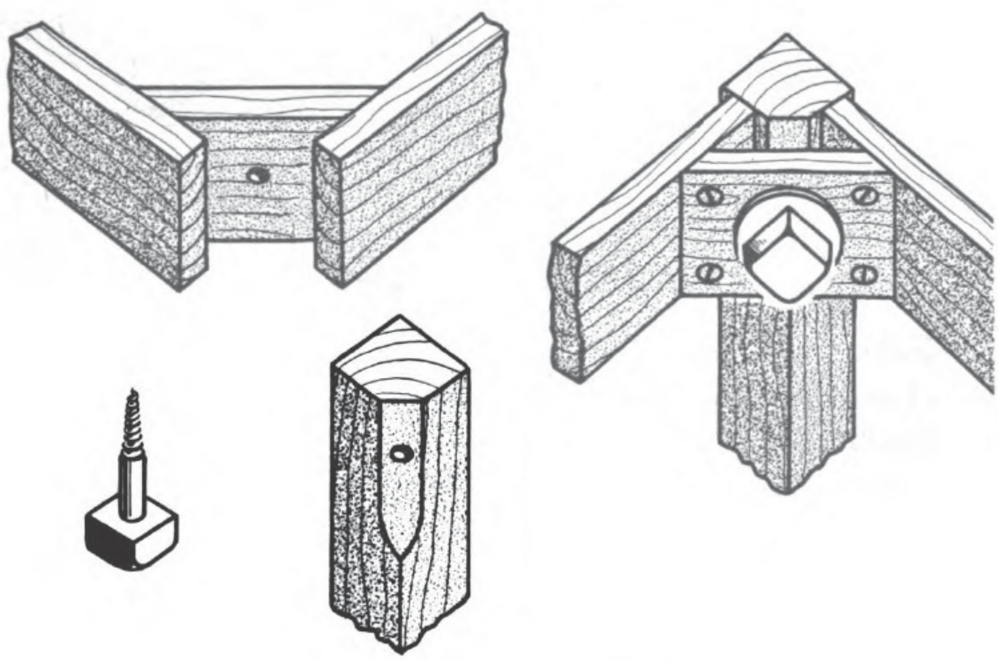


Figure 12–11.—Corner butt joint for table legs.

TABLE CONSTRUCTION

One standard method of making a table is illustrated in figure 12–10. Desks are made in much the same manner, with the panels and drawers added.

Mortise and tenon joints are used to join the table rails to the legs and to secure the stretcher to the lower end rails. An alternate method of securing the legs to the rails is by means of corner plates and lag screws. With the latter method, the legs can be tightened easily when they get loose and also removed easily. (See figure 12–11.)

Drawers for tables and desks may be made by the method shown in figure 12–12. It's easier to make drawers by this method than it is to make them with dovetail joints. However, blind dovetail joints are better and should be used for the front corners of drawers which are made of fine cabinet wood.

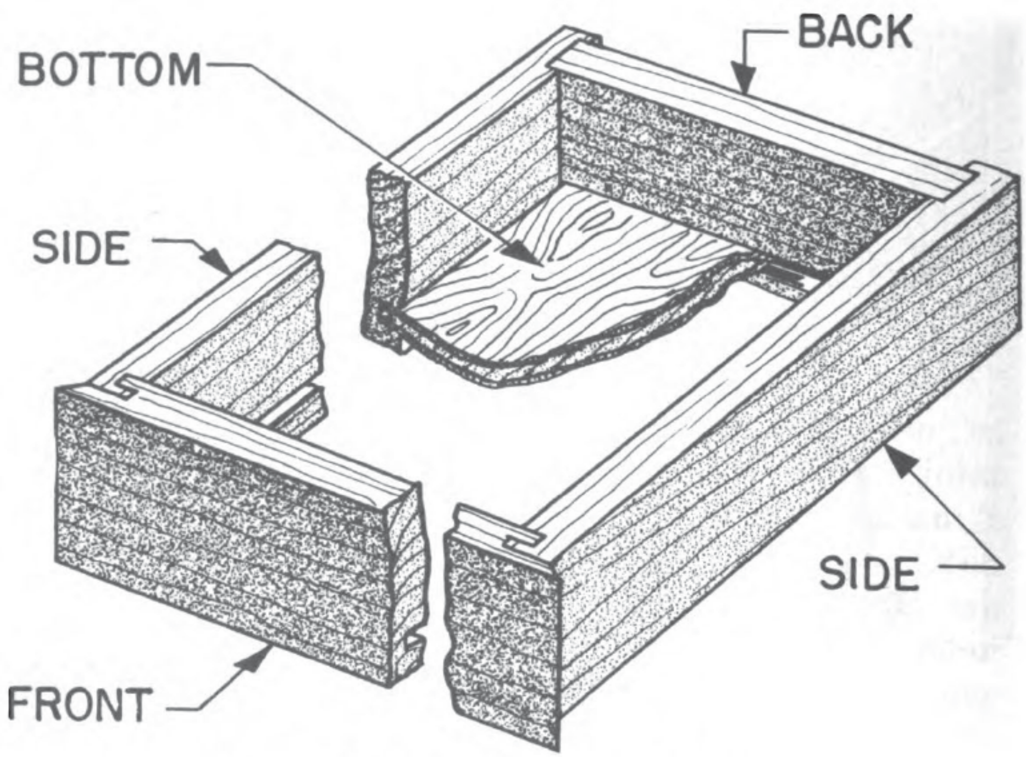


Figure 12–12.—Simple drawer construction.

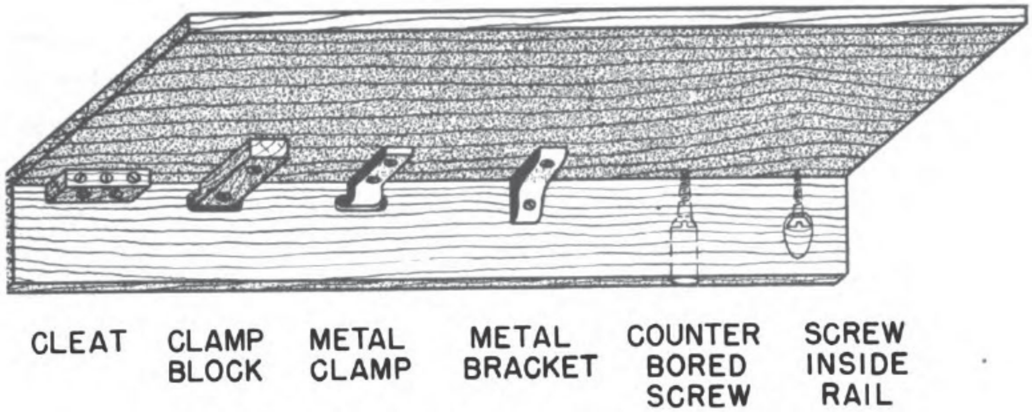


Figure 12-13.—Securing rails to table tops.

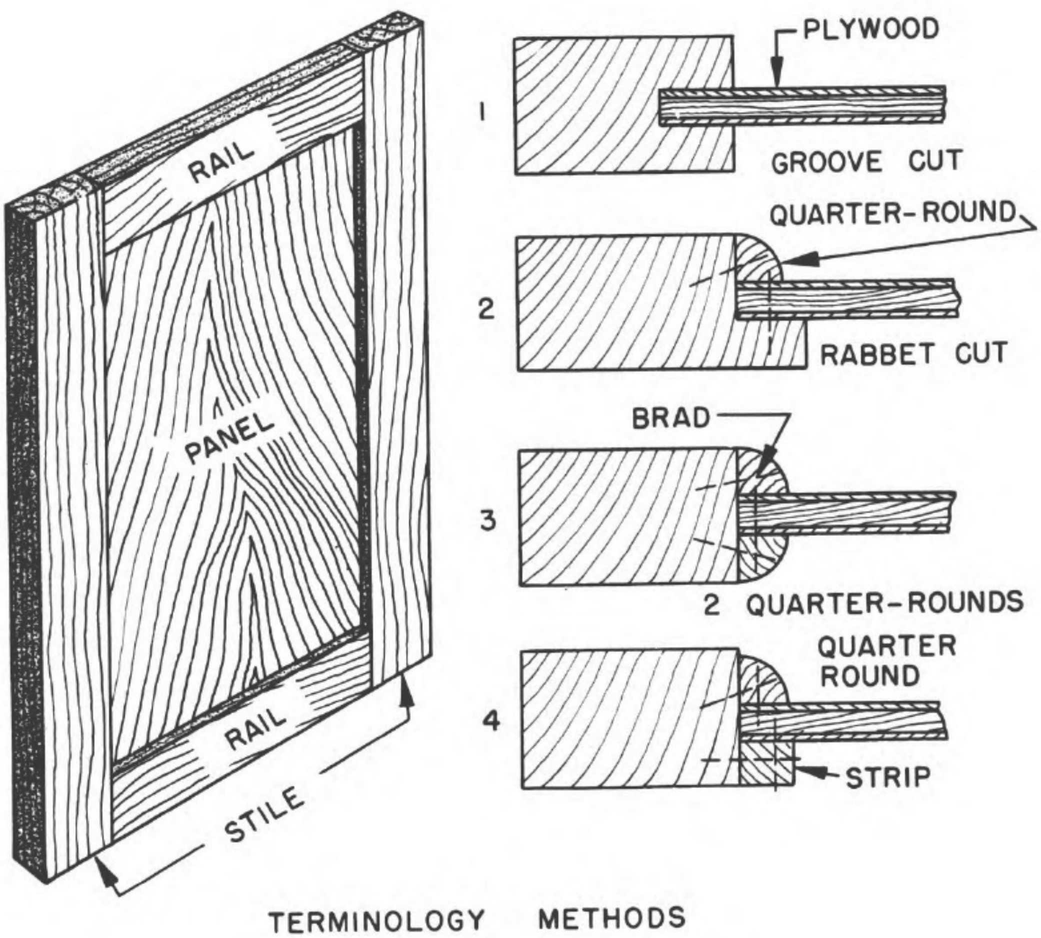


Figure 12-14.—Panel construction.

Table tops may be fastened to the upper rails by several standard methods. You will probably use the cleat more than any of the others. The cleat is screwed to the rail first until it is about 1/16″ below flush. Then the screws going into the top will pull the top down tight and snug. **(See figure 12–13.)**

PANEL CONSTRUCTION

Plywood panels are often installed in frames to make parts of doors, partitions, bulkheads, tables, desks, cabinets, lockers, drawers, bulletin boards, and blackboards. The panels may be installed by a number of methods. Four of the commonly used methods are shown in the sectional views. Fir plywood of ¼″ thickness is used more than any other material for panel construction. (See figure 12–14.)

GLUE USED IN WOODWORKING

Many devices are used for fastening wood. These include nails, screws, bolts, and glue. One of the oldest of these materials is glue. In museums, you will find Egyptian and Roman furniture which was assembled with glue hundreds of years ago. It is still in good condition. Good glue applied properly will form a joint which is stronger than the wood itself.

There are several classes of glue. Probably the best one for joint work and furniture construction is ANIMAL glue. It may be obtained commercially in a variety of forms—liquid, ground, chipped, flaked, powdered, or formed into sticks. The best grades of animal glue are made from hides. Some of the best bone glues, however, may give as good results as the low grades of hide glue.

FISH glue is a good all-around wood shop glue, but it is not as strong as animal glue. It is usually made in liquid form, and it has a disagreeable odor.

VEGETABLE glue is manufactured by a secret process

for use in some veneering work. It is NOT a satisfactory glue for wood joints.

CASEIN glue is made from milk in powdered form. The best grades of casein glue are water-resistant and are, therefore, excellent for forming waterproof joints. Casein glue, however, doesn't adhere well to oak. To join oak surfaces with it, coat the wood with a ten percent solution of caustic soda and allow it to dry. Then apply the casein glue to form a strong joint.

BLOOD ALBUMIN glue is also practically waterproof, but to use it, you would need very expensive equipment. It is, therefore, not often used.

PLASTIC RESIN glue may be procured in either liquid or powder form. It is durable and water resistant, but like casein glue, it doesn't adhere too well to oak. Plastic resin glue is used in the manufacture of balsa wood and plywood life floats.

You can make a good WATERPROOF glue by adding to the glue an amount of potassium bichromate or calcium chromate equal to one fiftieth of the volume of the glue.

MARINE glues are solutions of india rubber, shellac, asphaltum, or mixtures of these substances dissolved in benzene or naptha. They really aren't glues at all, but they are used in paying seams of wooden decks.

POINTERS FOR USING GLUE

Each type of glue must be prepared and used in a special manner if you are to get the strongest possible joint. Instructions are always found on the label of the container. Study these carefully before you attempt to use the glue. There are also certain general principles which you should follow when you apply any glue.

A lot depends on the wood itself. Dry wood makes stronger joints than wood which is not well seasoned. This is easy to understand if you'll remember that water in the wood will decrease the amount of glue which can be absorbed.

The surfaces to be joined together must be as true as possible. Glue used as a mortar to fill up gaps in an imperfect joint has very little strength. Maximum strength is obtained by the penetration of the glue into the pores of the wood. Sandpaper should *not* be used to smooth surfaces of wood to be glued. Powdered wood, when sanded off, fills up the pores of the wood and decreases the penetration of the glue. A keen cutting edge should be used for smoothing.

Be sure the glue pot is clean before you make up a batch of glue. Old glue left in the pot from a previous day will cause the glue you are preparing to sour and thus become greatly weakened. You'll have no difficulty in recognizing sour glue by its bad odor.

Glue is a lot like wine—it needs to age in sealed containers. Glue which has been in stock a long time is superior to newly manufactured glue only if the container has not been opened previously.

Fine grained woods require thin glue. The finer the pores in a wood, the thinner the glue solution must be. Porous woods work better with a more concentrated glue solution. A concentrated glue will not penetrate the pores of a dense wood sufficiently to make a strong joint. On the other hand, it is well to use a concentrated glue of about heavy cream consistency whenever possible since a thin glue is merely diluted and doesn't have the binding power of the concentrated form.

Do not heat glue any longer than necessary. Glue will lose 50 per cent of its strength in a day's heating. This means that you should never make up more glue than you are going to use immediately. And remember, remelted glue is not as strong as freshly prepared glue.

Animal glue should be warm enough to penetrate the pores of the wood so that it won't set before you have fitted the joint and applied pressure. If the temperature is too high, however, the glue will lose a lot of its strength. Glue should never be permitted to heat to the boiling point

as it will take only a few hours of boiling to destroy the glue completely. Always use a thermometer so that you can keep the temperature of the glue below 60° centigrade or 140° Fahrenheit.

The wood to which you are applying glue should also be warm, but not hot. If the wood is cold, the glue next to the wood will be chilled and will set before it has properly penetrated the pores of the joint. If the wood is hot, the water in the wood will be cooked out and the joint will warp. It's a good idea, also, to have the glue room warm so that the glue won't chill.

You should always apply pressure as quickly as you can after spreading glue. This keeps it from setting before the pieces are joined. Be sure to squeeze or rub any excess glue out of a joint before you apply pressure. You won't squeeze or rub out enough to weaken the joint.

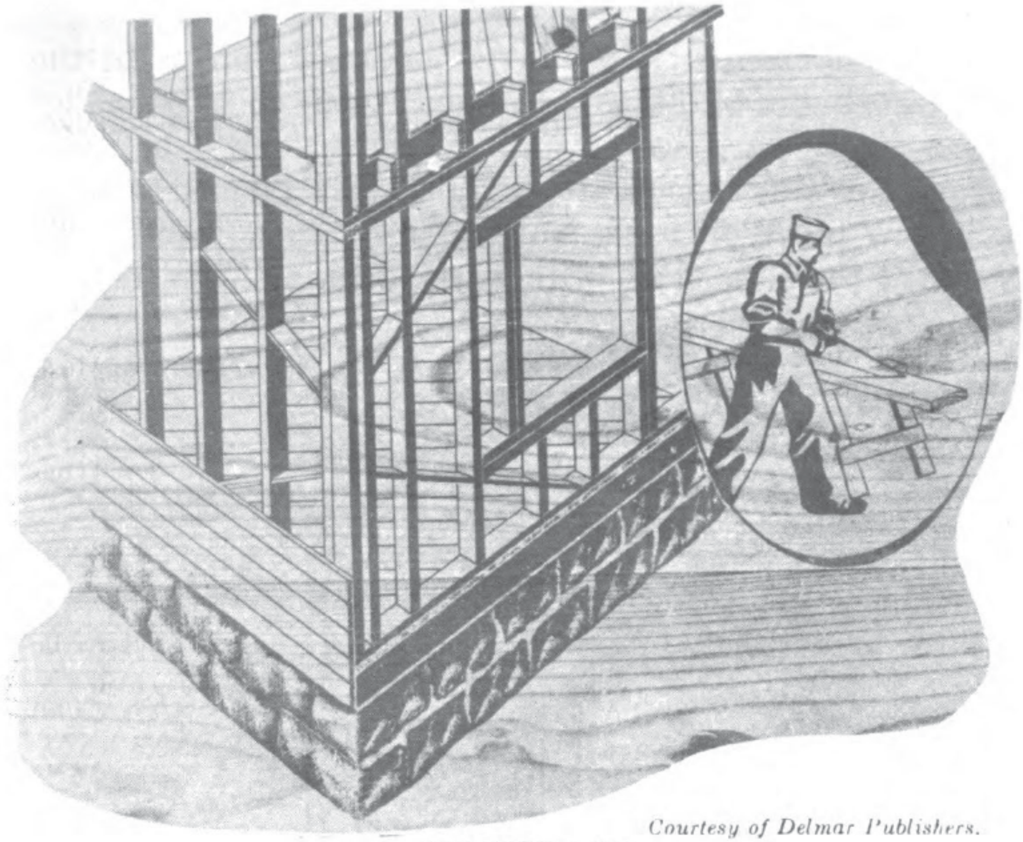
The greater the pressure, the stronger the joint will be, provided the pressure doesn't become great enough to crush the wood and injure the pores. Pressure should be at least 100 pounds per square inch to form the bond. The bond needs to consist only of the interlaced threads of glue passing from the pores in one piece to the pores in the other, so don't worry about squeezing out too much glue. Clamps or a vise may be used to produce the needed pressure.

Pressure should be maintained 10 to 12 hours, and then the joint should be cured for about 7 days to get maximum strength. If the pressure is removed too soon, the pieces will separate slightly, and break the joint before the glue is thoroughly dried; consequently, you'll get a weak joint.

The curing room should be kept at a warm temperature with a low humidity—that is—without much moisture in the air. If the room has a high humidity, it is almost impossible for the joint to dry completely. Don't heat the joint while it's being cured. Heating the joint keeps the glue in a liquid condition longer and produces a weak joint.

QUIZ

1. What are the four standard methods of joining boards edge-to-edge?
2. Describe the plain butt joint.
3. What is the most common use of the tongue-and-groove joint?
4. What is the scarf joint used for?
5. What are the joining pieces called when the end butt joint is used for joining short members to make long pieces?
6. Why is the dovetail an excellent joint for the corners of desk drawers or similar construction?
7. Name three uses of the miter joint?
8. What is the best glue for joint work and furniture construction?
9. Name four devices which are used to fasten wood.
10. Is vegetable glue a satisfactory glue for wood joints?
11. From what is casein glue made?
12. Should sandpaper be used to smooth surfaces of wood to be glued?
13. Why should you always apply pressure as quickly as you can after spreading the glue?



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CHAPTER 13

FRAMING

FRAMING THE SUPERSTRUCTURE

Just as the skeleton is an essential part of the human body, so is the frame an essential part of a wooden building. The strength and durability of a structure depend upon the strength of its framework.

Framing consists of the basic members of the walls, floors, and the roof. When we speak of the walls, we should consider partitions as well as outside side walls. Floors include stairs, and the roof includes subordinate roofs over porches, balconies, and extensions (ells) at right angles to the length of the main building. Framework in a brick or stone building is similar to that in a wooden building.

In colonial days, timber was abundant, but the means of manufacturing it into lumber were primitive. There-

fore, it was cheaper to use large pieces of timber for the framework of a building than to cut them up into smaller sizes. Nails were scarce and expensive, but labor was cheap. For this reason, the early settlers framed wooden members together with mortise and tenon joints, and fastened them in place with wooden pins. This method

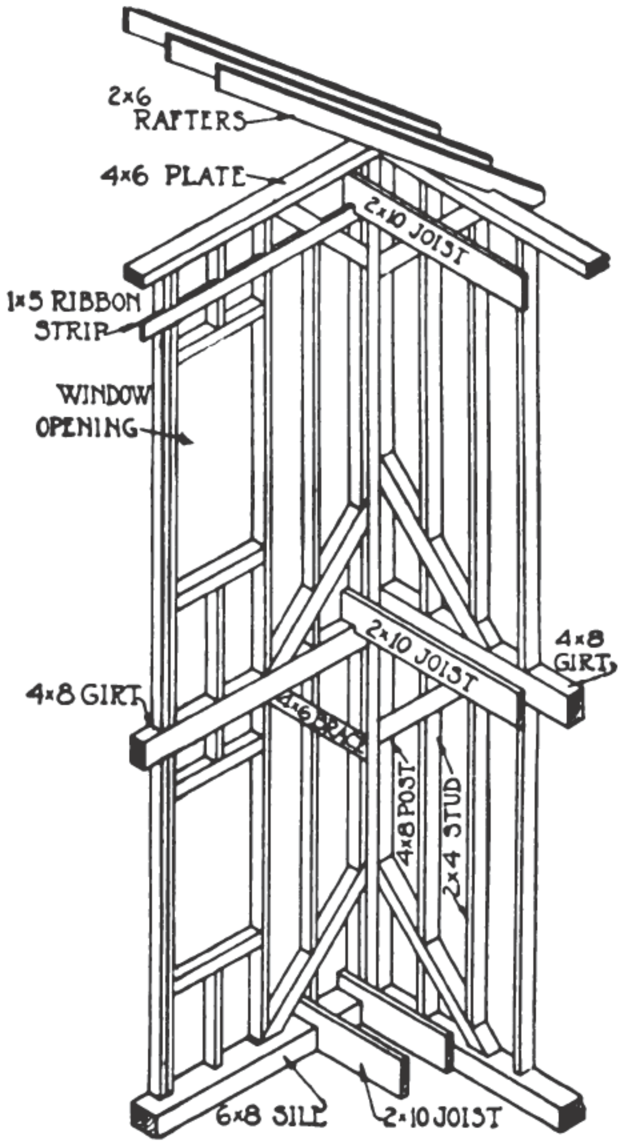

Figure 13–1.—Full framing.

of framing was called FULL FRAMING. (See figure 13–1.) It was used until about the middle of the nineteenth century when lumber become more expensive. At this time, the machines for producing lumber in smaller sizes

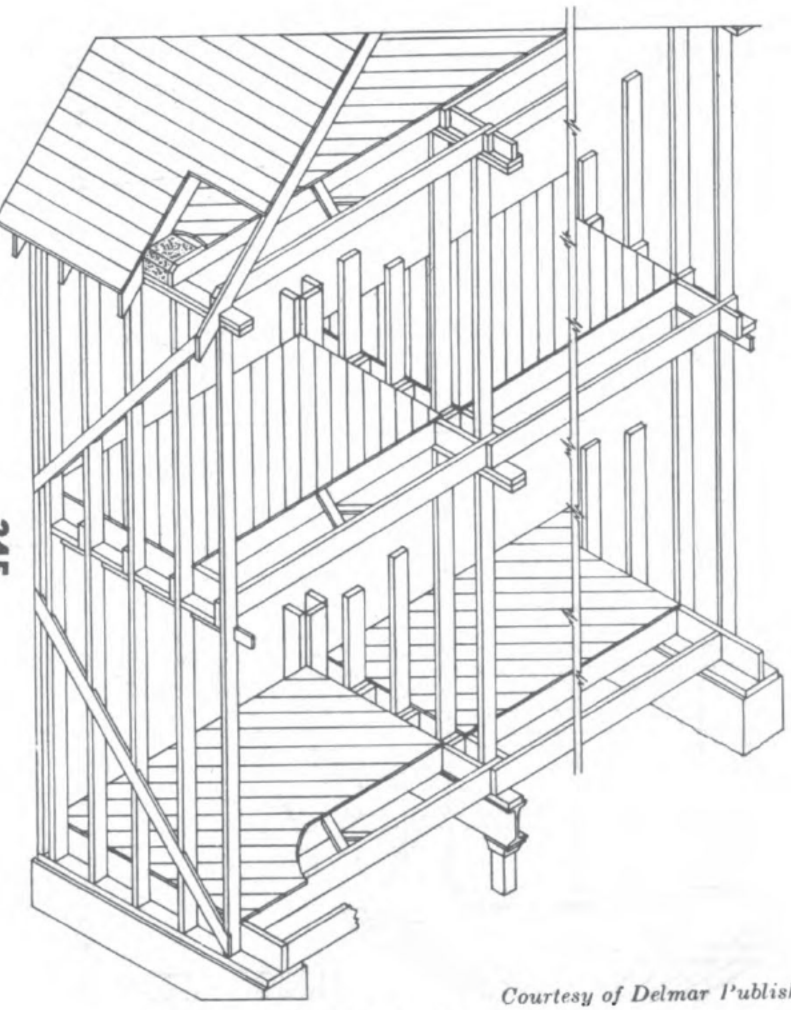

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Figure 13-2.—(a) Braced balloon framing.

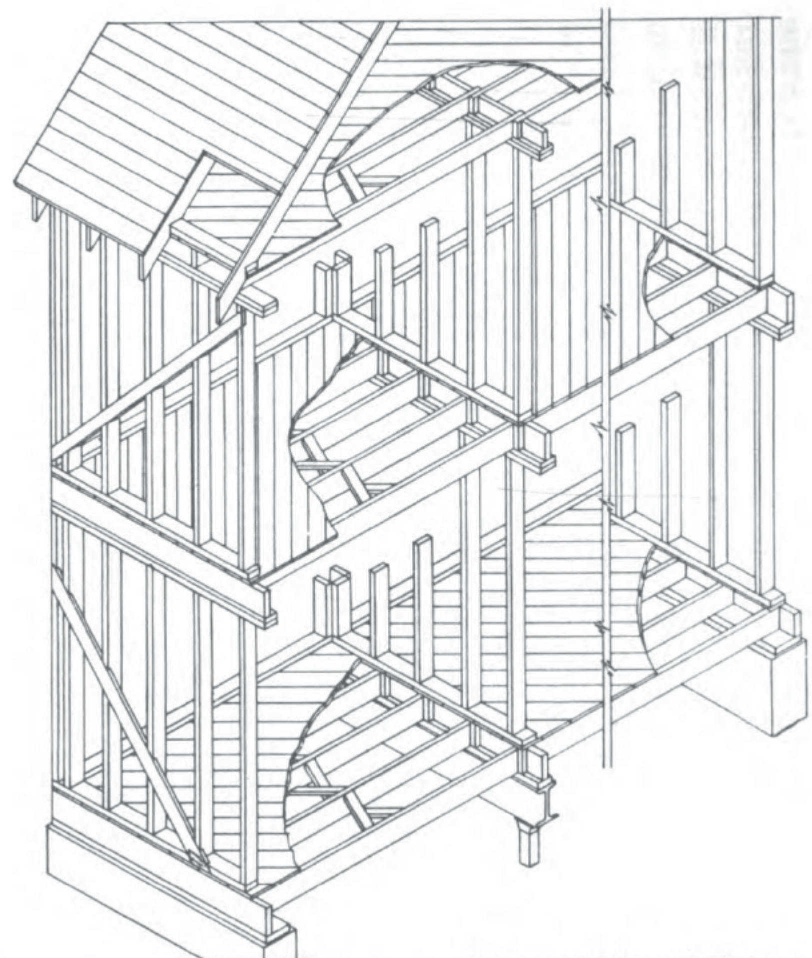

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Figure 13-2.—(b) Platform framing.

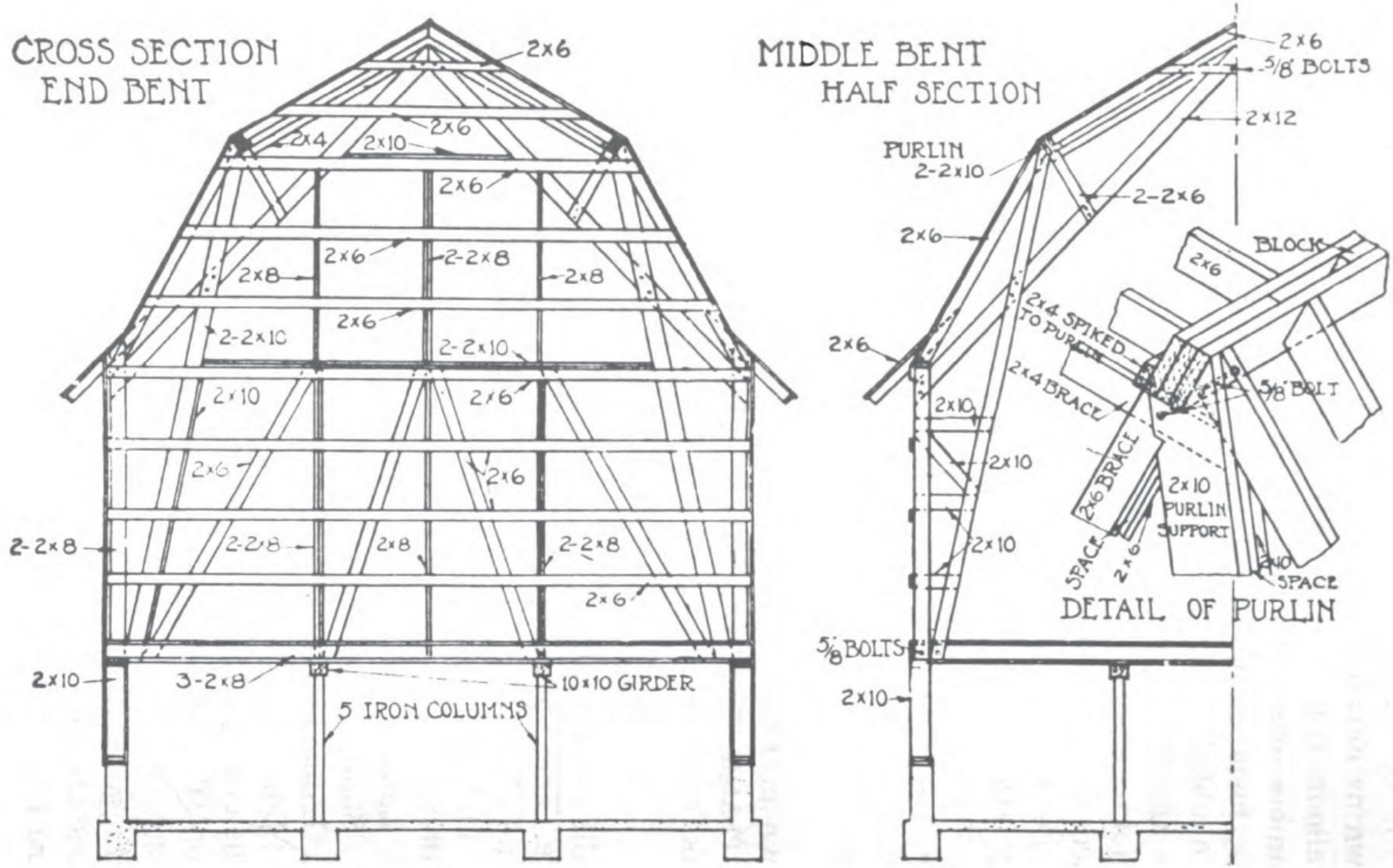


Figure 13–3.—Plank frame barn.

were more highly developed. Then, the modern method known as BALLOON FRAMING originated.

Balloon framing is done by using only small pieces of lumber or scantlings. In this type of framing, where a single member of greater strength is needed, scantlings are doubled or trebled and nailed together. Moreover, nails and spikes are more plentiful and wages higher, so the joints are fastened by spiking instead of by pegging. Braces are used in balloon framing so that the frame can be raised as a unit rather than piece by piece. They also make the building more rigid. It is necessary to brace such a frame strongly at all corners in order to hold it square and true while it is being raised. An example of braced balloon framing is shown in figure 13–2a. Today, the vast majority of buildings, in which wood is the material used, are constructed by what is known as PLATFORM FRAMING in houses (see figure 13–2b) and PLANK FRAMING in barns. Figure 13–3 illustrates a plank frame barn.

INSTALLING SILLS AND GIRDERS

Sills are the first members of a frame that you set in place. These members rest directly on the foundation and extend all around the building, with splices where necessary and with joints at all corners. There are four types of sills:

1. Laminated.
2. Solid.
3. Lapped.
4. Box.

The LAMINATED SILL is made up of two or more timbers set on edge and spiked together to make the sill strong enough to bear the structure. These laminations should be staggered at the joints, as shown in figure 13–4.

A SOLID SILL consists of one piece of timber. (See figure 13–5.) This type is preferred over the laminated sill because of the added strength and easy, quick installa-

tion. All joints in the solid sill should be halved. You should join solid sills directly over the foundation piers if the structure is supported by this type of foundation.

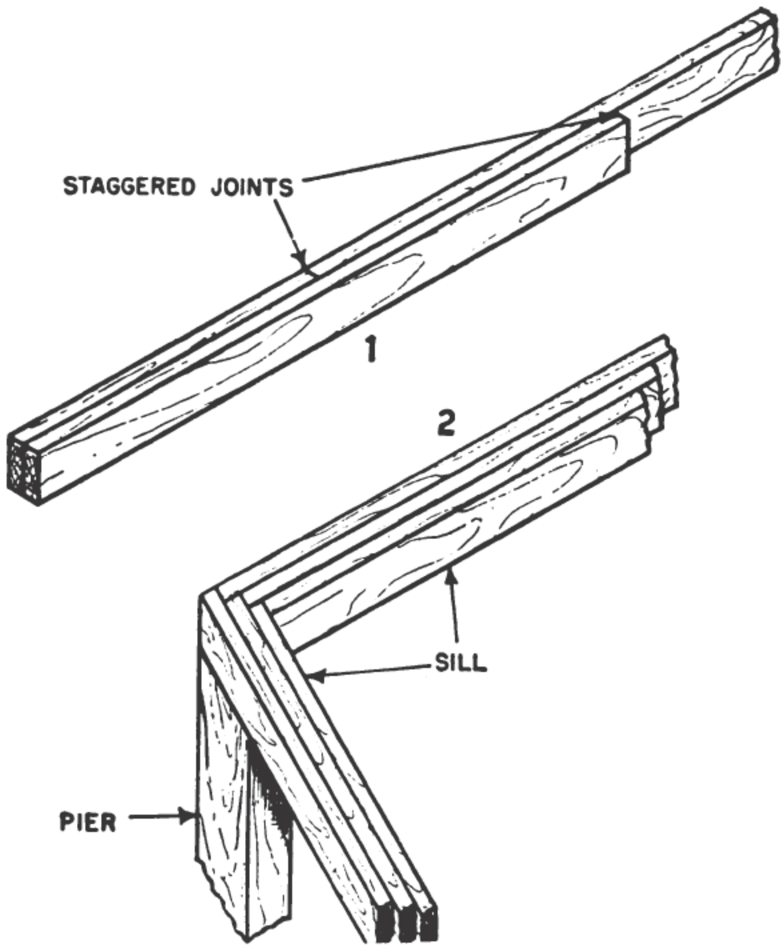


Figure 13-4.—Staggered laminated-joint sill.

A LAPPED SILL is made up of two members laid flat on a solid foundation. Their primary purpose is to receive the floor joists and serve as a nailing surface for the header blocks between the floor joists. (See figure 13-6.)

The BOX SILL is generally used when continuous foundation walls support the structure. This sill consists of two pieces of wood. One rests flat on the foundation and is called the SILL PLATE, while the other piece is laid edgewise on the outside edge of the sill plate. The three methods of box sill construction are shown in figure 13-7.

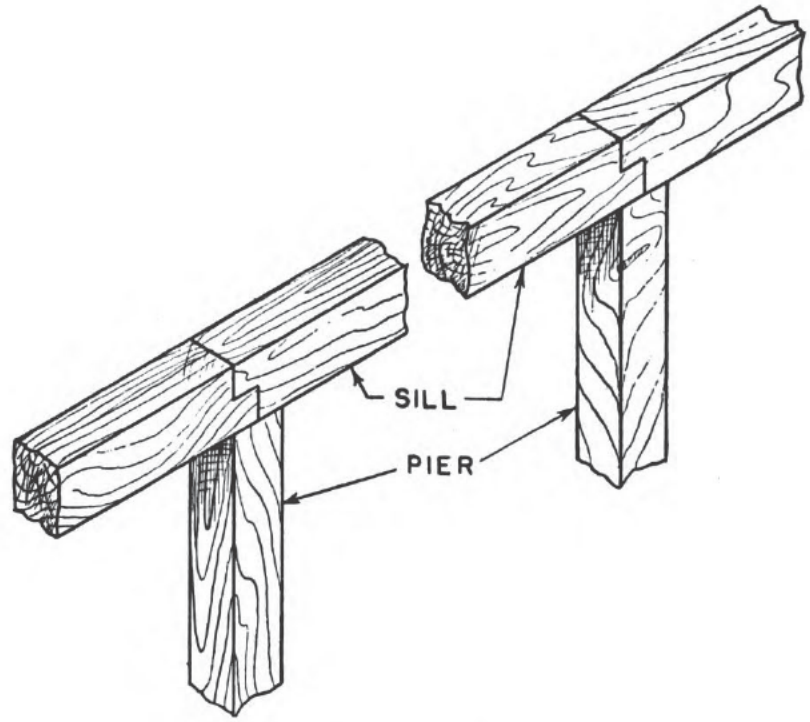


Figure 13–5.—A solid sill.

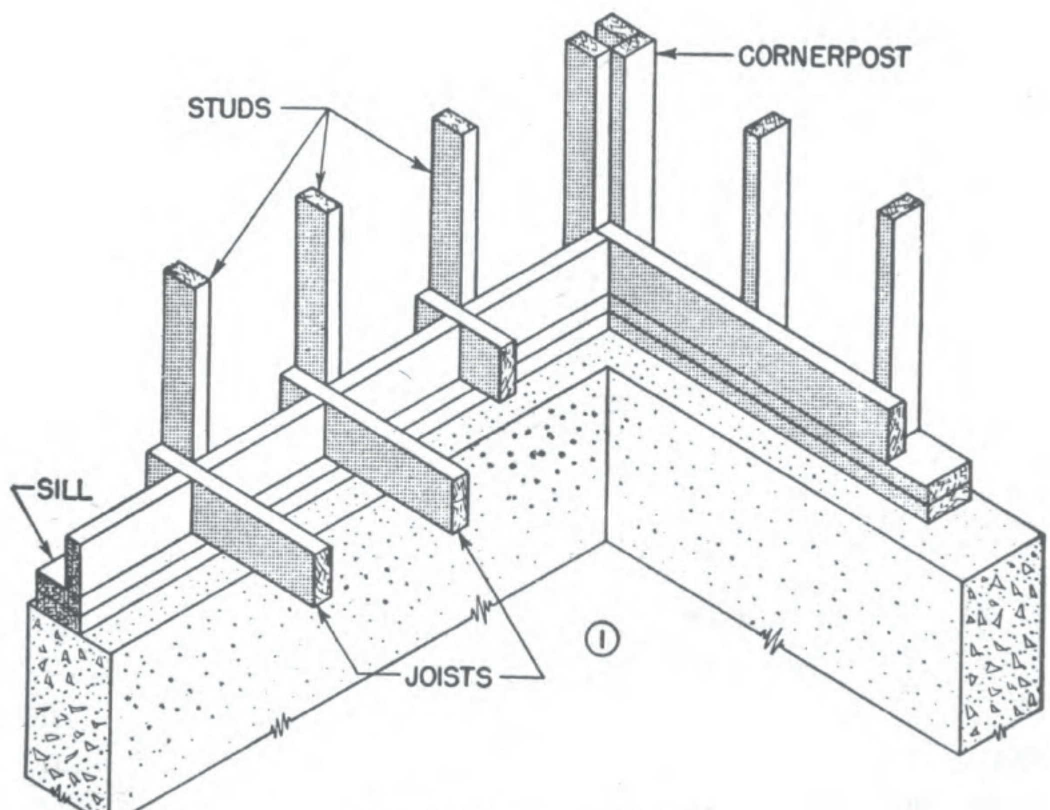


Figure 13–6.—Lapped sill.

On solid foundations, the sill is the means of joining the structure to the foundation. In most cases, particularly light frame structures, anchor bolts are set into the masonry at intervals of from 8 to 10 feet. These bolts extend up through holes bored in the sill (as shown in

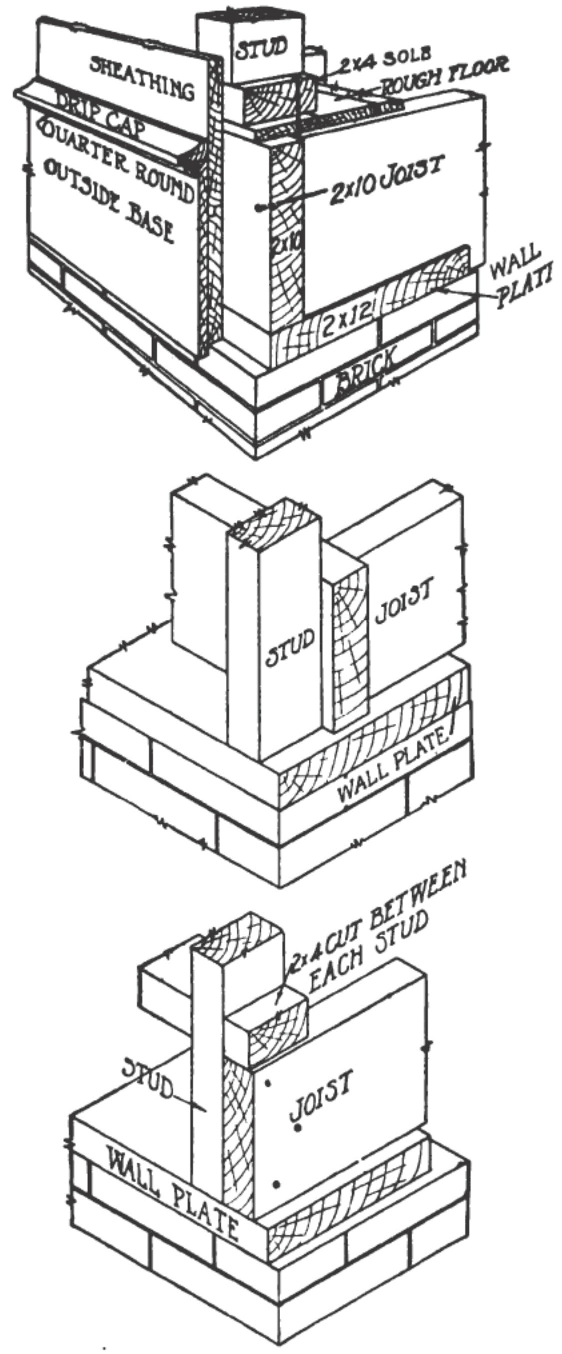
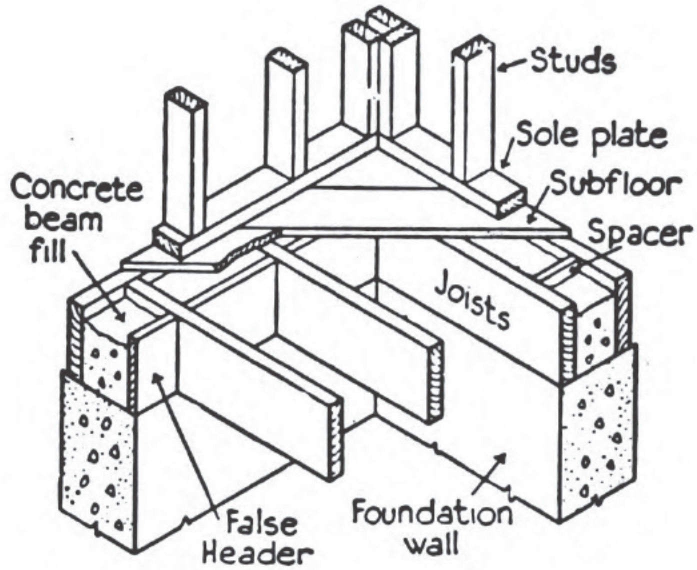


Figure 13–7.—Three methods of box sill construction.

figure 13–8) to receive them. They are fastened at the top of the sill with a nut screwed down tight on a washer. By this method you fasten the sill, and therefore the



Box Sill Assembly Without Sill Plate.

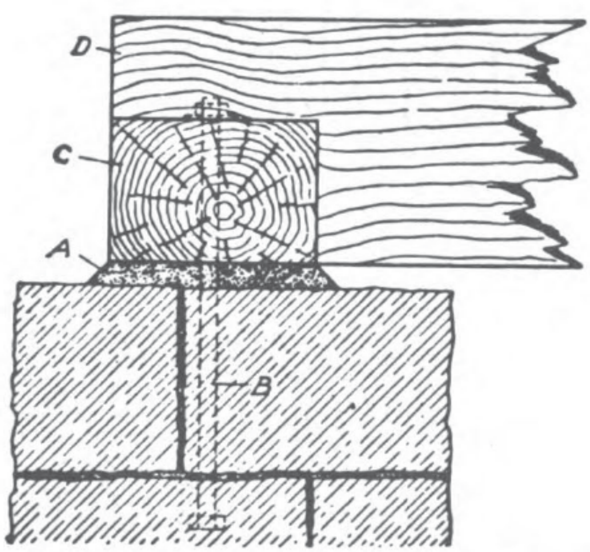


Figure 13–8.—Method of setting underpinning, sill, and joists.

whole frame, securely to the foundation. When the undersides of sills rest on concrete foundations, you should apply a couple of coats of linseed oil to the underside of

the sill to keep it from absorbing moisture from the masonry. On pier or column foundations, the sill carries the load of the structure and also supports the weight of the floor between the piers or columns. The size of the sill depends upon the load to be carried. When pier foundations are used, the size of the sill is also determined by the spacing of the piers. Figure 13–9A illustrates a built-up girder and a method for framing the joists to it. Three 2 x 10's, with 2 x 4's spiked to each side, form the girder. The advantage of this type of girder over the type shown in figure 13–9B lies mainly in the fact that it leaves more headroom. However, the second type is easier to frame and is, therefore, generally used.

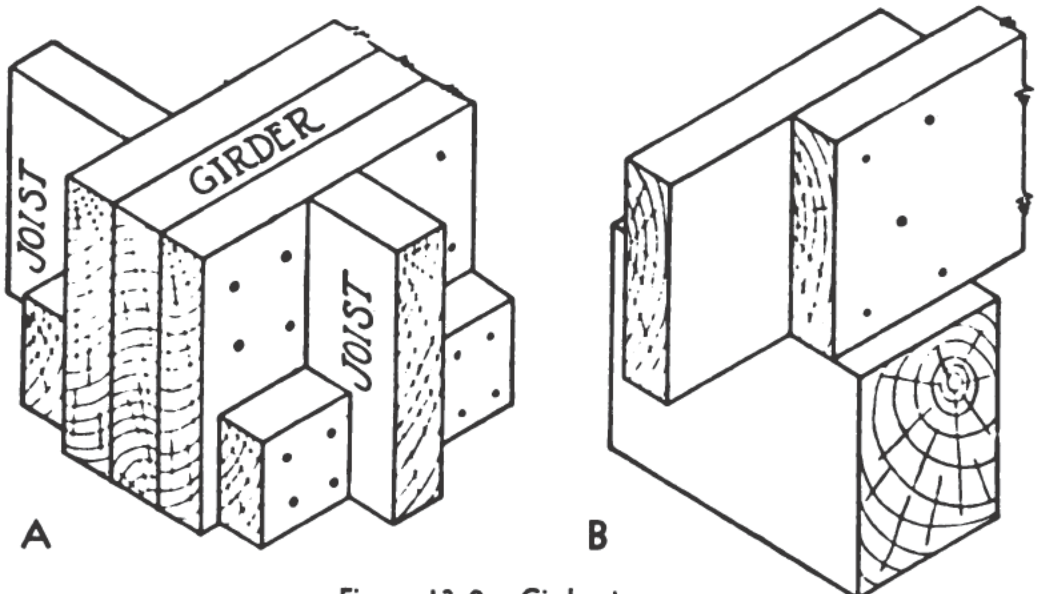


Figure 13–9.—Girder types.

JOISTS

Joists are members which make up the body of the floor frame. Subflooring is nailed to the joists. Joists should be of 2-inch material, with the width determined by the dead and live weight of the structure. The weight of the joists combined with the weight of the subflooring and flooring is called the DEAD LOAD. Proposed weight of material and personnel is referred to as the LIVE LOAD.

Nails and spikes are commonly used to join joists to sills. Joists are supported at one or both ends of the sill. A COMMON JOIST is one that extends from one sill to the other and helps support the uniform load. A CARRYING JOIST is one that extends and is spaced directly under a partition. Carrying joists are usually placed in pairs, spaced about 4 inches apart, to carry the added weight of the partition. These two joists should be far enough apart to project a little on each side of the partition, as shown at *AA* in figure 13–10, to give a nailing surface for the finished flooring. Plank or solid bridging should be placed between such joists at intervals of from 14 to 20 inches to stiffen them. However, the subfloor is often put in place as soon as the joists are laid. Then, the

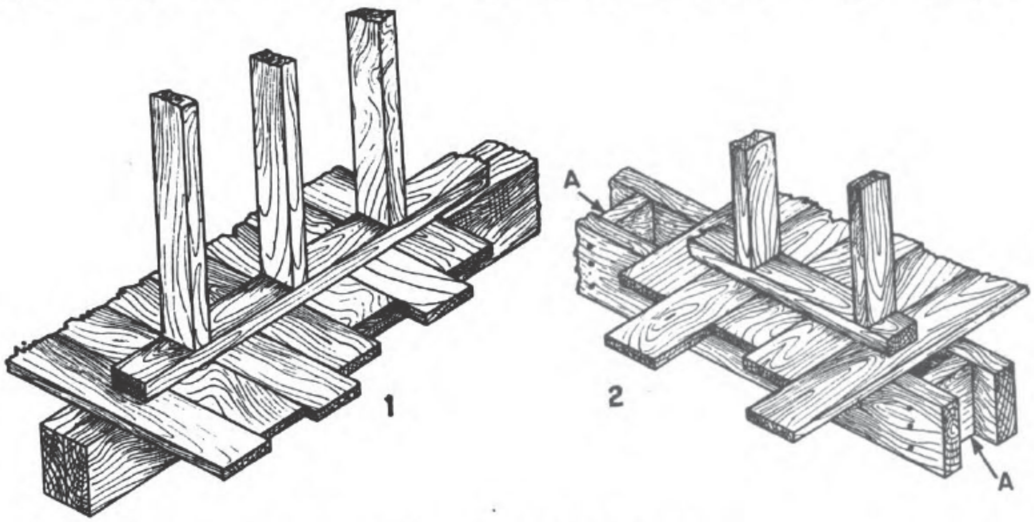


Figure 13–10.—Partition joist support.

carrying joists are doubled and spiked together, forming one unit.

A HEADER JOIST is a short transverse joist which supports the ends of one or more joists that are cut off to form a well hole for a stairway or an opening in the floor frame. The short cut-off joists are called TAIL JOISTS. The joist known as the trimmer is placed and made fast to the common joist or it may be placed at the well hole or opening, as indicated in figure 13–11. In order to prevent joists from springing sideways under a heavy

load, you should install supports, known as bridging. The two kinds of bridging supports are:

1. Herringbone or cross-bridging.
2. Solid or plank bridging.

HERRINGBONE or CROSS-BRIDGING is preferred for use in floor frames to stiffen the frame to prevent unequal deflection of the joists and to enable an overloaded joist to get some assistance from the joists on either side of it. This diagonal bridging consists of pieces of scantling,

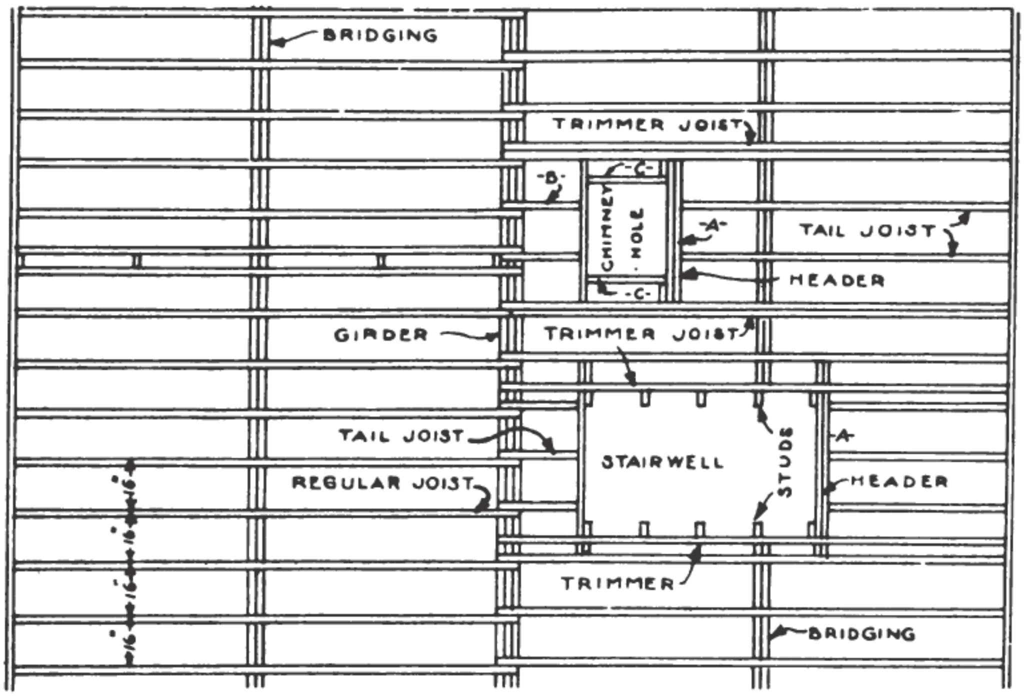


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Figure 13–11.—Trimmer, header, and tail joists.

usually 1 x 3 or 2 x 3 inches in size, cut in diagonally between the floor joists, as shown in figure 13–12A.

You'll notice that each piece is nailed to the top of one joist and to the bottom of the next joist. Also notice that the two pieces which cross each other are placed close together between the same two joists, forming a cross. It is from this cross that you get the name "cross-bridging." The bridging should be placed in straight lines at intervals of 8 to 10 feet, forming continuous trusses across the whole length of the floor.

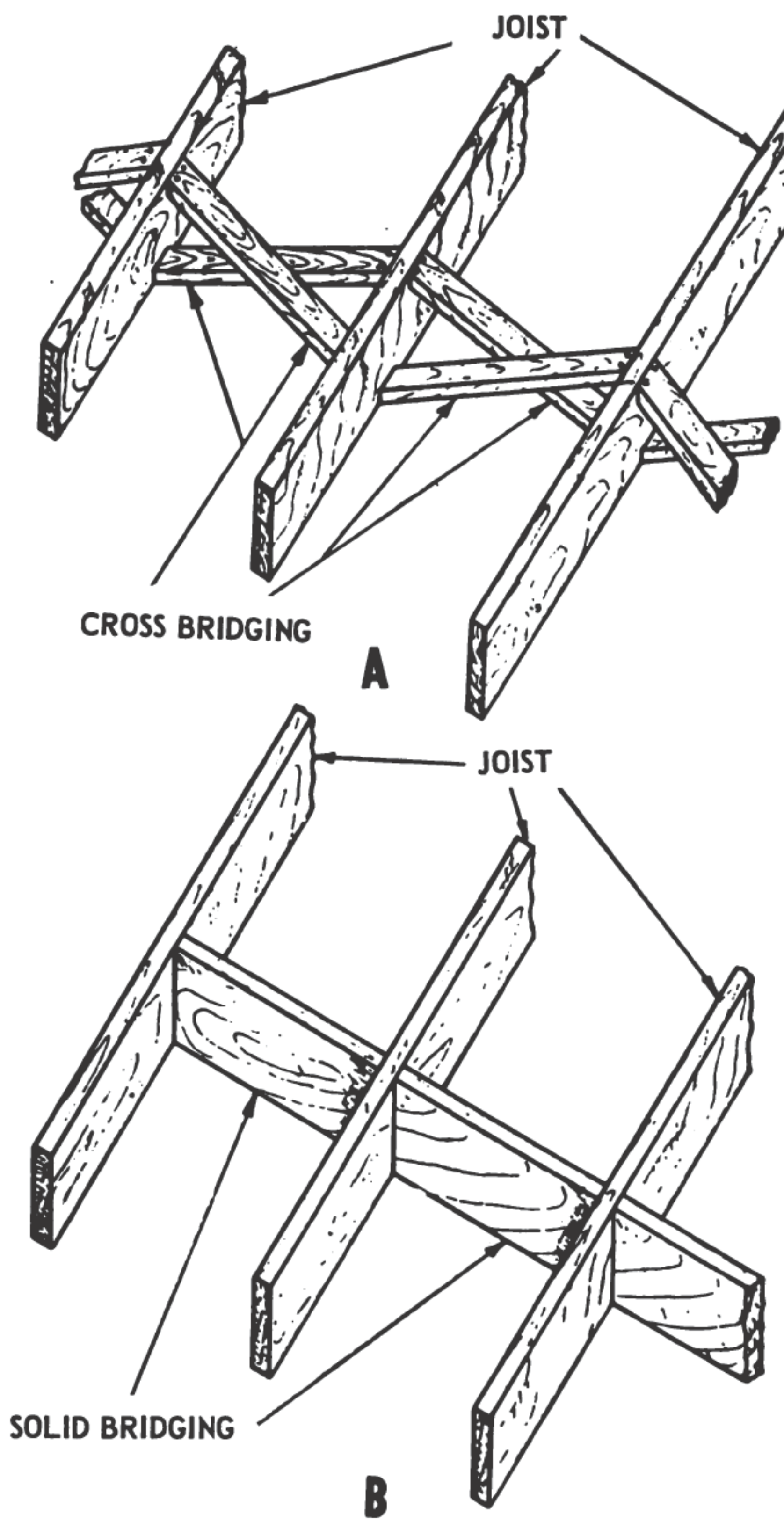


Figure 13-12.—Bridging between joists.

When possible, nail only the top of the bridging at first. When the joists have adjusted themselves to their final position, the lower ends of the pieces of bridging are fastened in place against the joists from underneath.

SOLID BRIDGING is made by placing small blocks of the same width as the joists between the joists. They are placed in a vertical position, tying the joists together and causing the joists to share the load.

SUBFLOORING AND FLOORING

You should lay all subflooring diagonal to the joists to give additional strength to a structure. Then place finished flooring at 90° angles to the joists. This insures better nailing as you can nail through the subflooring into the floor joists themselves. Ordinarily, 6-inch tongue and groove sheathing is used. The same kind of material used for subfloors is also used for exterior sheathing. Subflooring may be laid either before or after the walls are framed. It's better to lay it before, so you can use it as a deck to work on while you are framing the walls.

STAIRS OR STEPS

Stairs or steps are built on a frame called a stringer or a carriage. Material 2 or 3 inches thick and 4 or more inches wide should be selected for the stringers or carriages. Blocks are nailed to 2 x 4's or 2 x 6's to form steps, but if you use material such as 2 x 10's or 2 x 12's, then you'll cut the stringers to form the steps. To construct a stairway of sound structure, you should erect the stair with at least three stringers, one at each of the two outer edges and one at the center.

In overseas construction, you may sometimes build step or stair stringers with 2 x 4's by nailing triangular blocks to one edge to form the stringer. Cut the blocks from 2 x 6's, as shown in figure 13–13 (2), and then fasten them to the 2 x 4, as indicated in figure 13–13 (1). The step stringers are secured at the top and bottom as

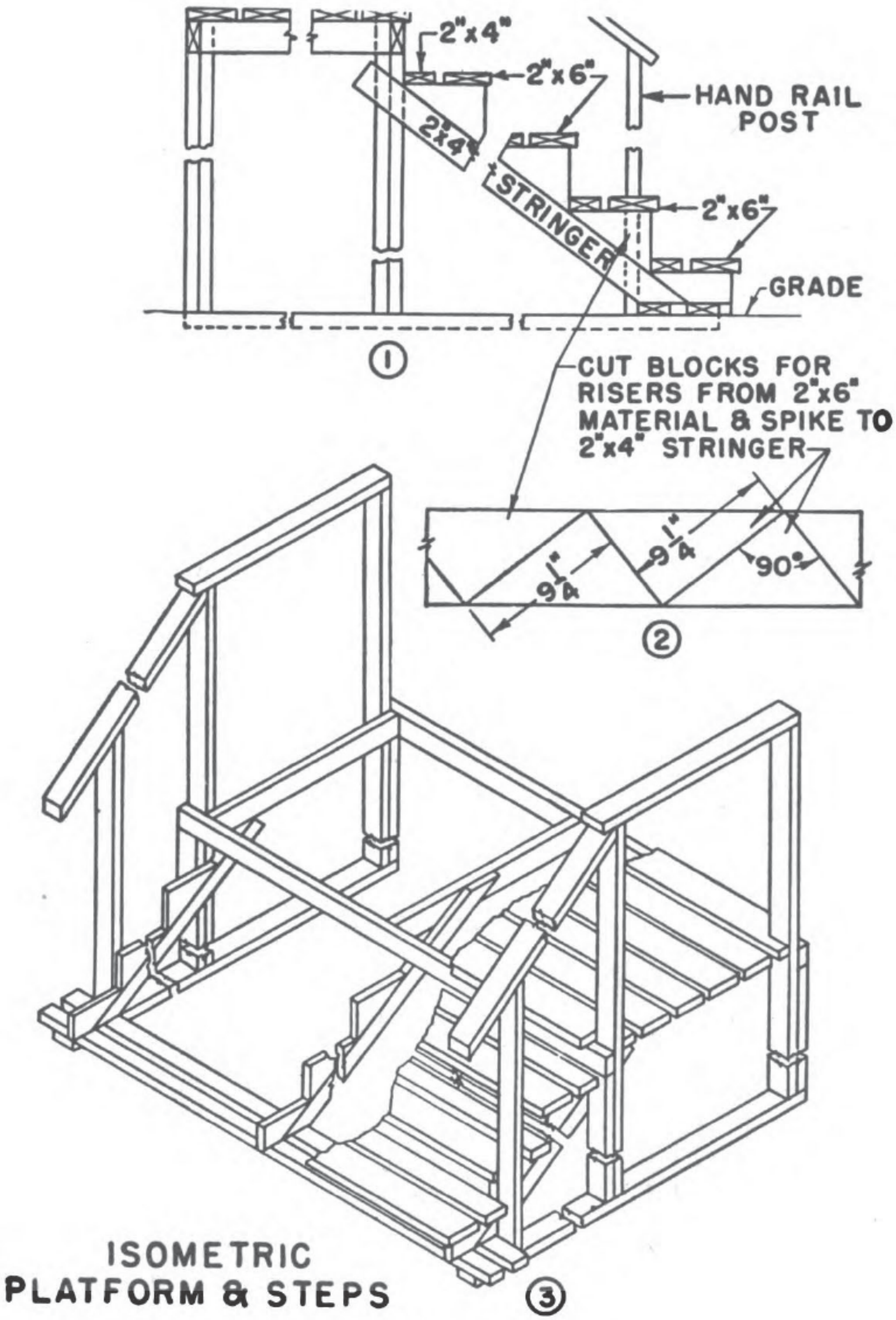


Figure 13–13.—Step details.

shown in figure 13–13 (1). In figure 13–13 (3), a method for installing the foundation is clearly shown. Notice in the same figure, the details of the sizes of the step treads, handrails, and posts. Construction and method of installing are also illustrated. When you use 2 x 10's or 2 x 12's for stringers, lay them out with the steel square, as indicated in figure 13–14.

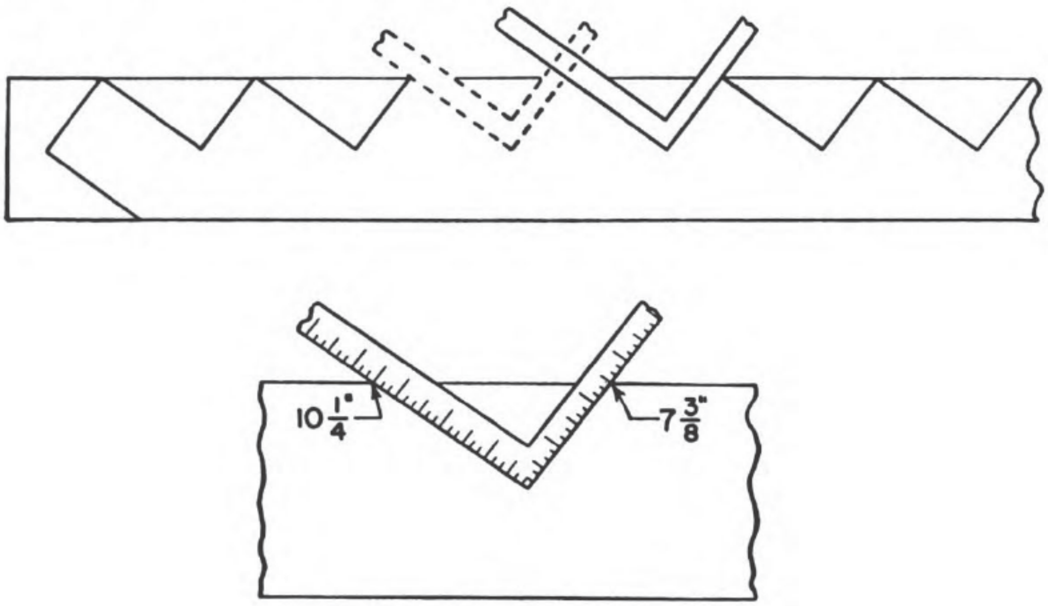
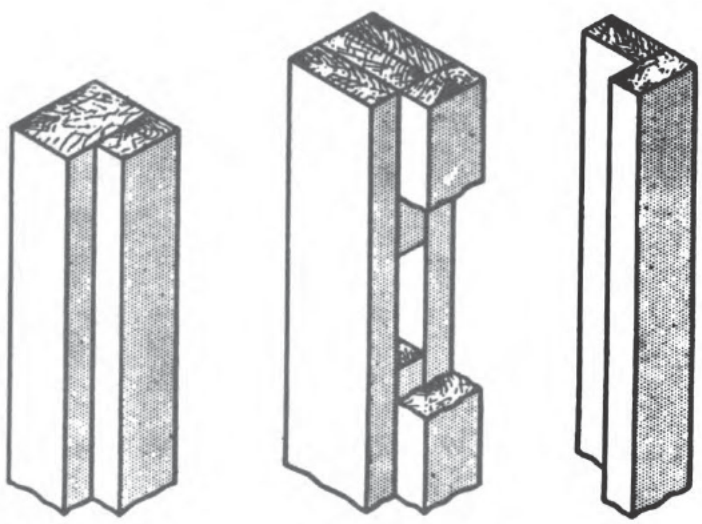


Figure 13–14.—Method of laying out step.



1 2 3

Figure 13–15.—Corner post construction.

CONSTRUCTING CORNER POSTS

After you have placed the sill and first-floor joists and installed the subflooring to give surface upon which to work, your next building step is to construct corner posts. The corner posts may be made in three different ways. (See figure 13–15.)

You'll observe that the first post may consist of a 4 x 6 with a 2 x 4 face nailed with one edge flush. You should use this type when you are putting in a 4-inch side wall. Heavier timber should be used for a thicker wall. The second post consists of two 2 x 4's,

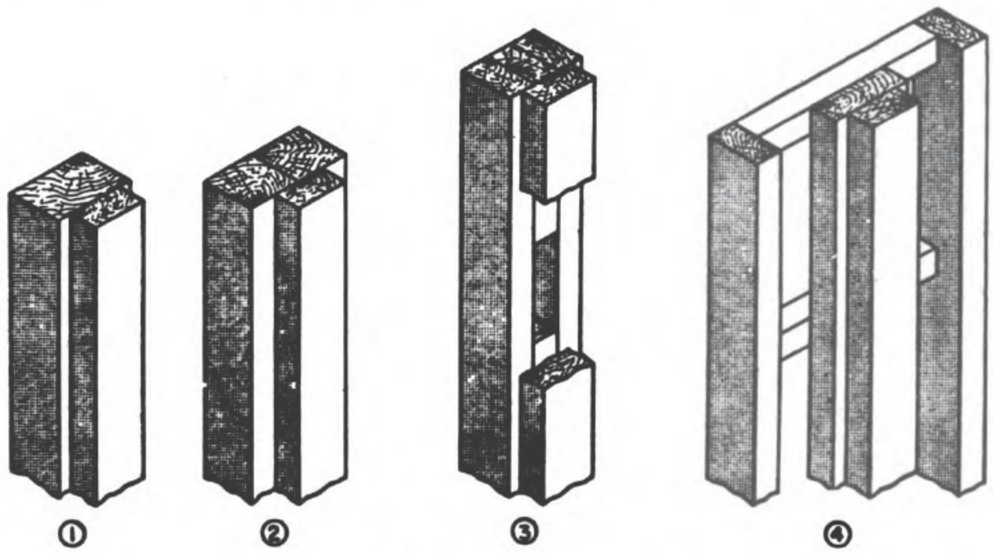


Figure 13–16.—T-post construction.

with blocks between them, and a 2 x 4 flush, with one edge fastened together. A third post may be made by nailing one 2 x 4 to the edge of another. The edge of one is placed flush with the side of the other. This type is generally used where no interior finish is required, such as for field construction in advanced areas.

THE USE OF T-POSTS

When a partition meets an outside wall, a stud called a T-POST must be installed. T-posts should be wide enough

to extend beyond the partition on both sides so as to furnish a solid nailing base for the interior wall finish. The T-post may be made in four different ways (see figure 13–16):

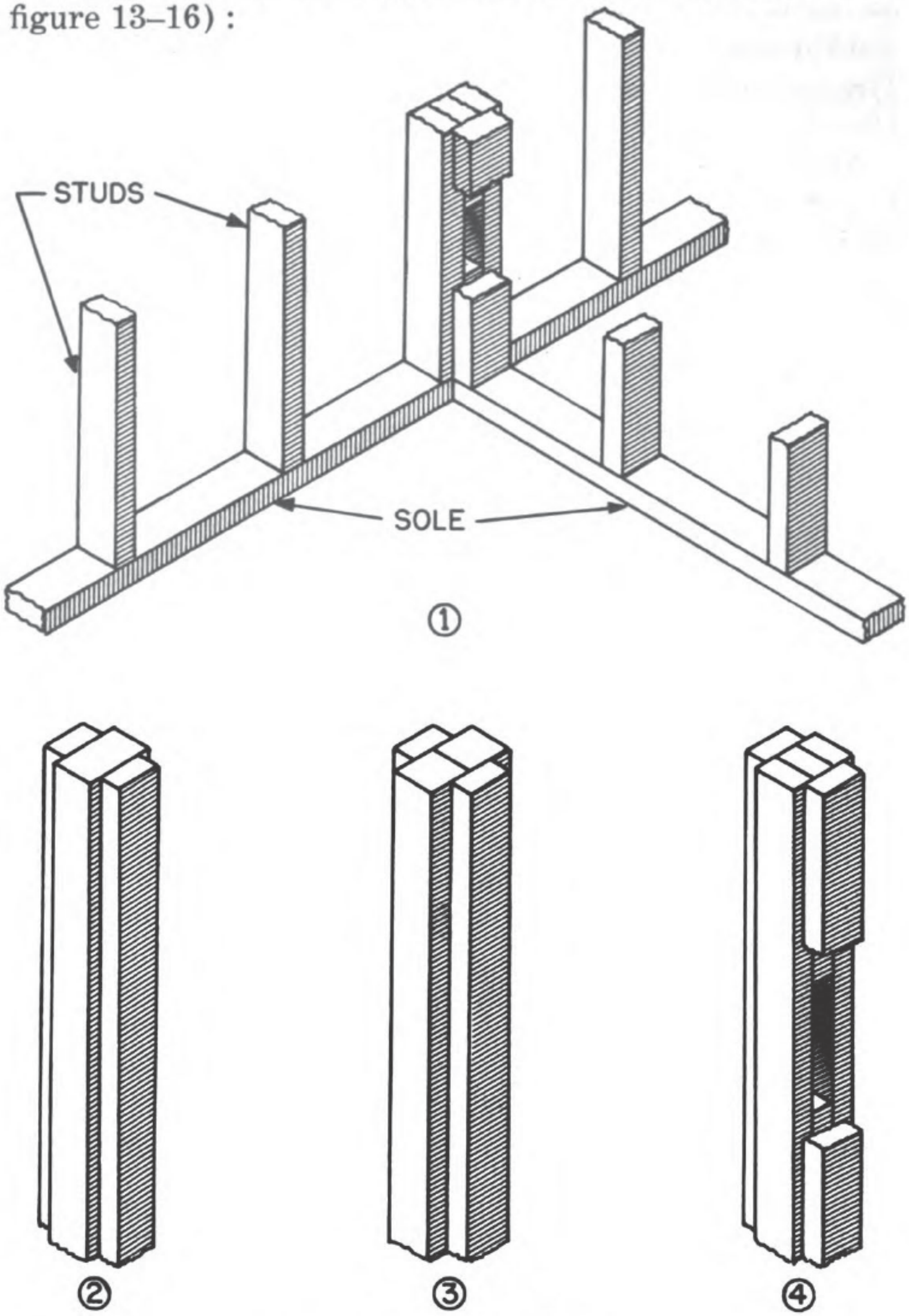


Figure 13–17.—Double T-post.

1. A 2 x 4 may be nailed and centered on the face side of a 4 x 6.

2. A 2 x 4 may be nailed and centered on two 4 x 4's nailed together.

3. Two 2 x 4's may be nailed together with a block between them and a 2 x 4 centered on the wide side.

4. A 2 x 4 may be nailed and centered on the face side of a 2 x 6, with horizontal bridging nailed behind them to give support and stiffness.

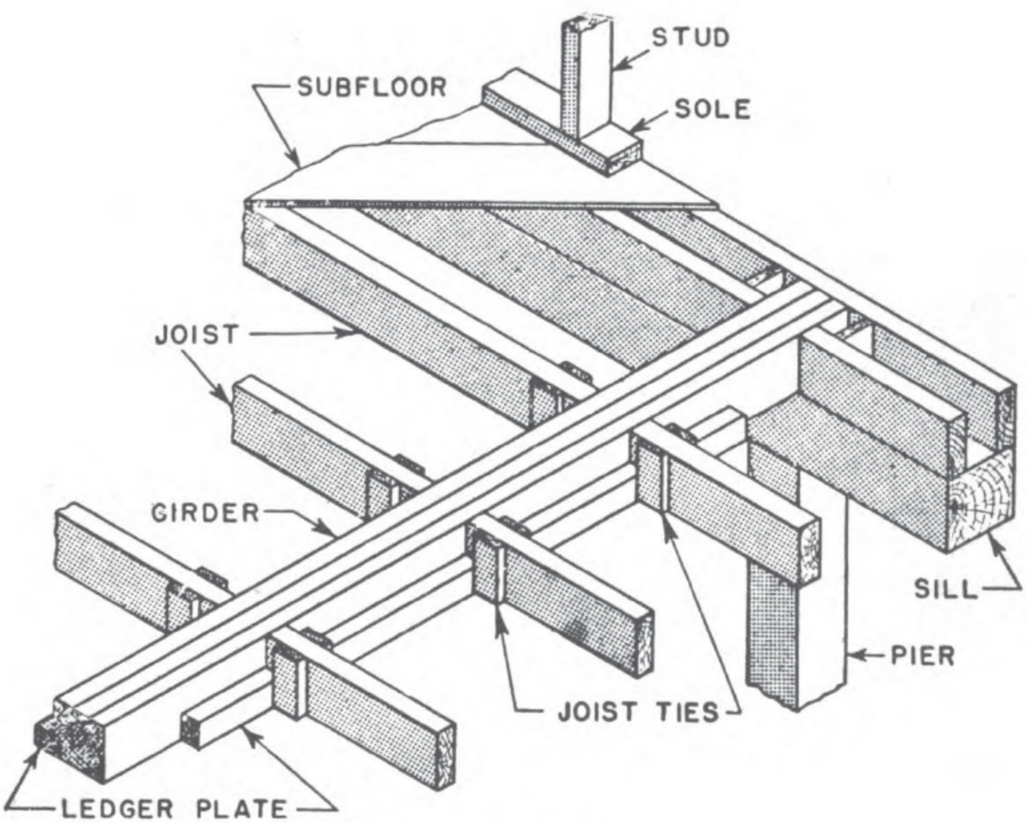


Figure 13–18.—Floor framing.

In cases where partition walls cross, you should use a double T-post. By referring to figure 13–17, you'll see that these double T-posts are made simply by nailing another 2 x 4 to the opposite wide side of T-posts, made by methods (1), (2), or (3) in figure 13–16.

A LEDGER PLATE is a member nailed to the face of the sill or girder, flush with the bottom edge. This ledger plate serves to connect joists to girders and sills, where piers are used for foundations. The ledger plate is secured to the sill or girder by 20-d nails about 12 inches apart. When the floor joists used in a structure are 2 x 4's, 2 x 6's or 2 x 8's, it is well to use 2 x 2's for the ledger plates, so as to prevent the joists from splitting at the notch. When the joists are 10 inches deep or deeper, you may use 2 x 4's for ledger plates without reducing the strength of the joists. In cases where a notch is used, you should use joist ties, as shown in

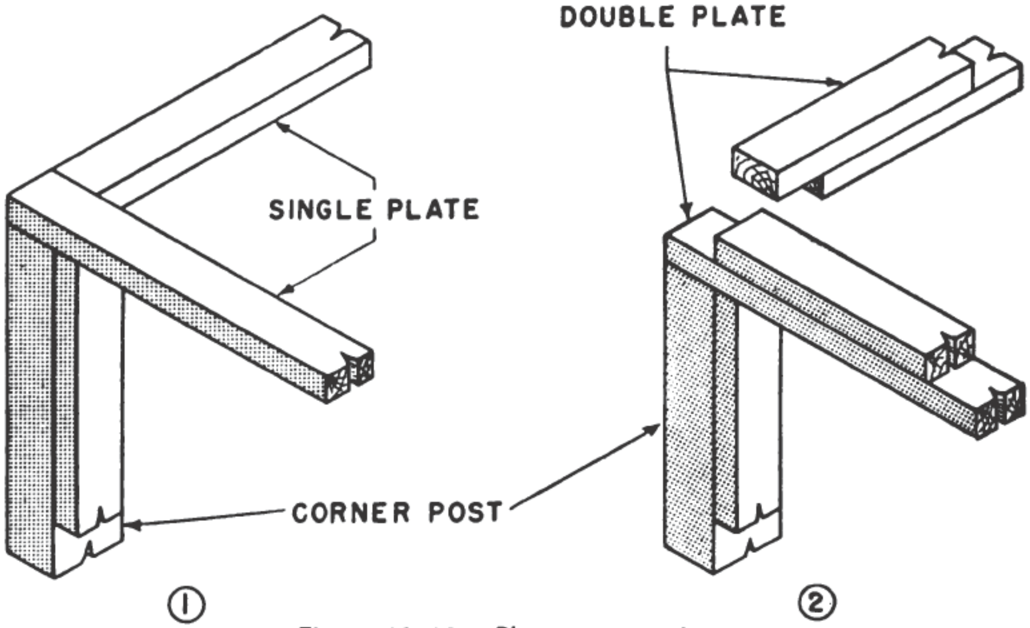


Figure 13–19.—Plate construction.

figure 13–18, in order to overcome this loss of strength.

The TOP PLATE serves three essential purposes, (1) to tie the studding together at the top and form a finish for the walls, (2) to act as a support for the lower ends of the rafters, (3) to support the ceiling joists.

You'll quickly see that the top plate serves as a connecting link between the wall and the roof, just as the sills and girders are connecting links between the floors and the walls. Always make up the plate with one or

two pieces of timber of the same size as the studs. You'll frequently use top plates that are doubled. A double plate is made by nailing the first plate or bottom section to the top of the corner posts and to the studs; the connection being made at the corner, as shown in figure 13–19 (1). Securing the single plate and corner braces in place, the top part of the plate is then made fast to the bottom section in such a manner that the edges of the top section are flush with the edges of the bottom

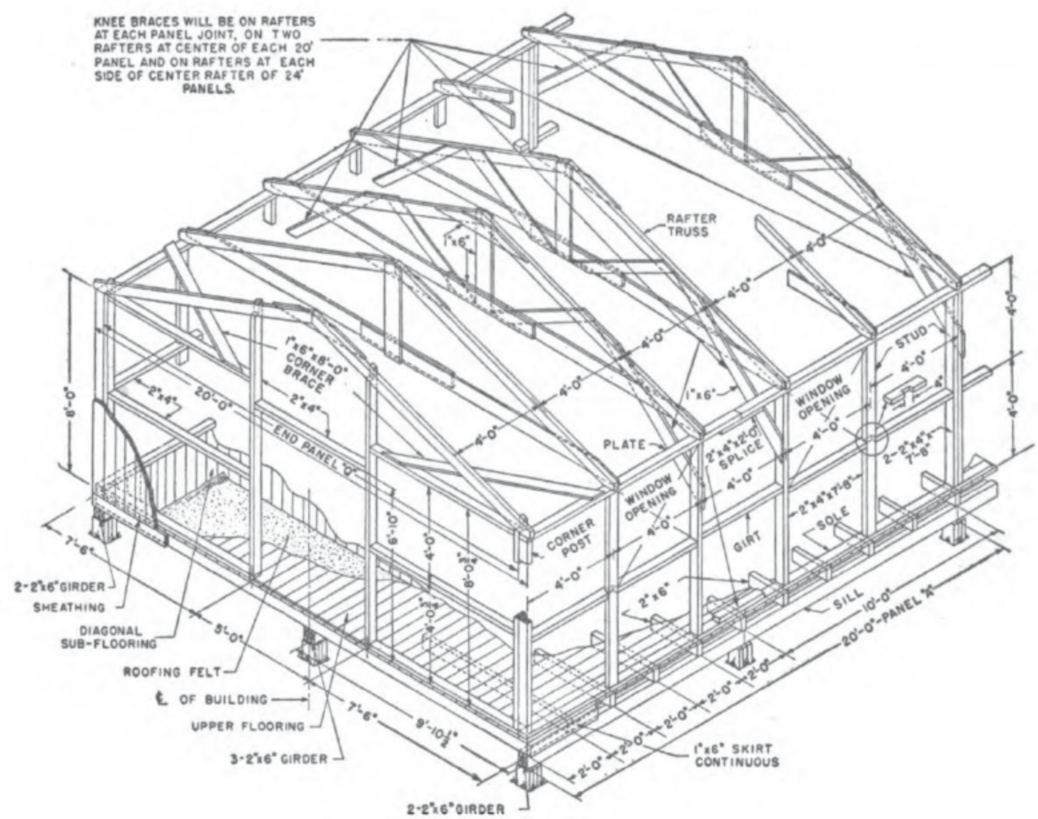


Figure 13–20.—Structural framing.

section, and the corner joints are lapped, as shown in figure 13–19 (2).

A SOLE PLATE is a 2 x 4 or timber that carries the bottom end of the studs. The sole plate is laid horizontally on the floor or joists. All partitions and outside walls should be finished with a sole plate corresponding to the thickness of the wall.

BRACES AND GIRTS

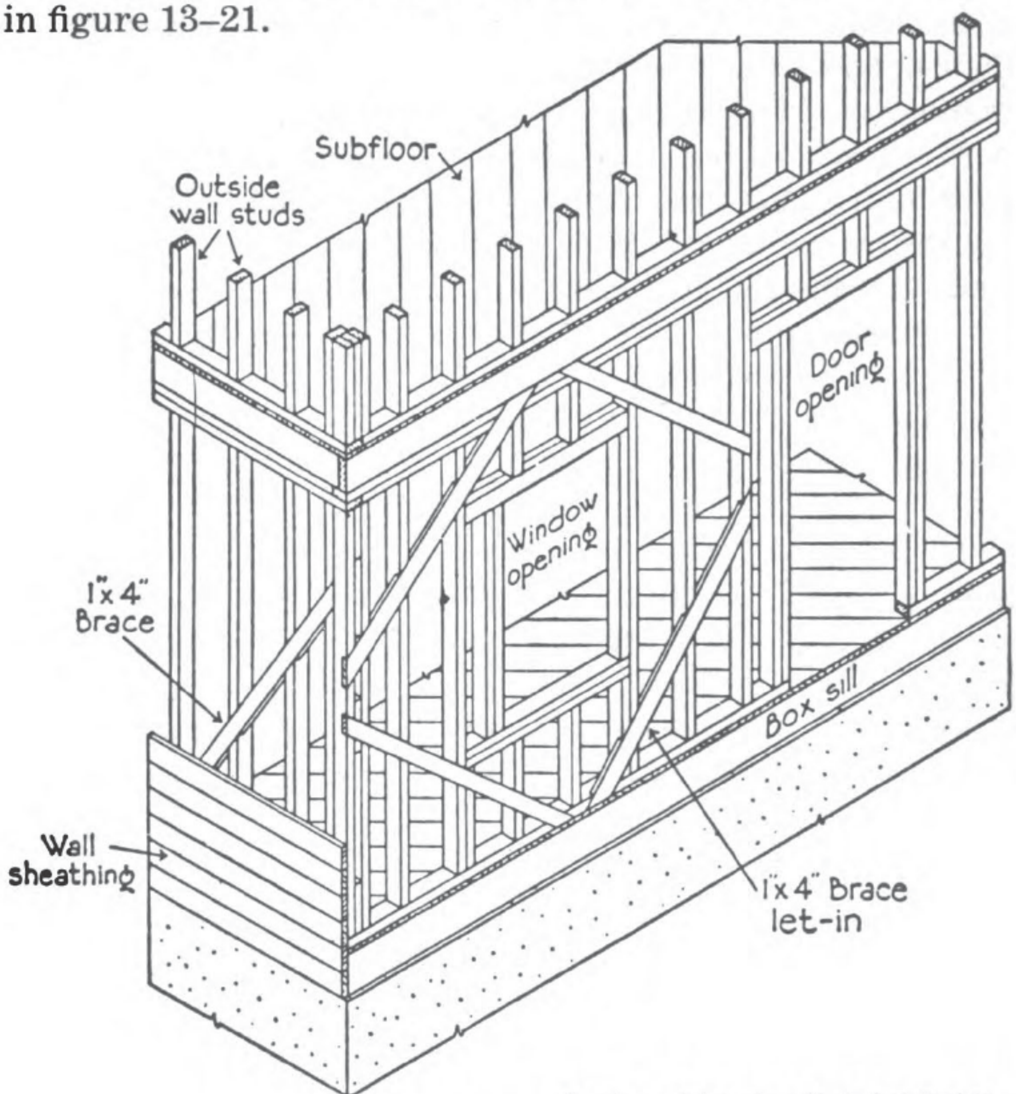
You should install braces in framing wherever the sills, girts, or plates make an angle with a corner post or with a T-post in the outside wall. BRACES serve to stiffen the walls, to keep the corners square and plumb, and to prevent the frame from being distorted by a lateral force, such as wind. You should place braces so that they extend from the sill or sole plate to the top of the plate or post. Install them at an angle of 60° with the sill or sole and at an angle of 30° with the post. Braces placed between the studs should always be of the same size material as the stud. In field construction in advanced areas, GIRTS are used where the outside walls are covered with vertical sheathing or siding. Girts should be made of material of the same width as the studs, and placed flush with both the inside and outside face of the stud. Studs are placed from $1\frac{1}{3}$ to 12 feet apart, with girts, spaced about 4 feet apart, running horizontally between them. (See figure 13–20.) Vertical siding acts in the same manner as studs and helps to carry the weight of the roof. In frame construction, where haste is not the prime factor, braces should be notched into the structural members and spiked. Notched studs give the best bracing. This type of bracing is called LET-IN bracing and is shown in figure 13–21. In the figure also notice the sill, and the wall studs.

HOW TO PLACE STUDDING

After you have placed the sills, you are then ready to complete the framing of the wall. Window and door openings should be laid out according to the architect's plans and specifications. Then the studs are laid out on the soles by measuring, from one corner, the distances the studs are to be set apart. Studs should be set from $1\frac{1}{3}$ to 12 feet apart, depending upon the type of building and the type of outside and inside finish. There are two kinds of studding, (1) the members which form the

frames for the door and window openings, and (2) the members which are installed to supply a nailing surface for the exterior and interior side walls.

Window openings are framed with top and bottom headers, and door openings with top headers, as shown in figure 13–21.



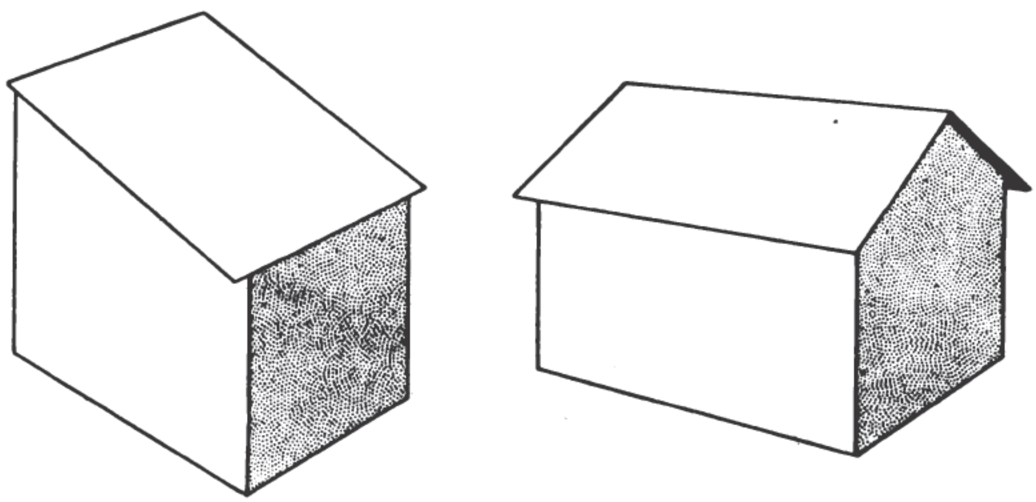
Courtesy of American Technical Society.

Figure 13–21.—Framing of openings.

INSTALLING PARTITIONS

Partition walls divide the interior space of a building. You'll usually frame partition walls as part of the structure. However, in cases where floors are to be installed after the outside of the building is completed, you'll leave

the partition walls unframed. There are two types of partition walls; the bearing type which supports ceiling joists, and the nonbearing type which supports only itself. The nonbearing type may be put in at any time after you install the other framework. You should frame partition walls in the same manner as outside walls. The door openings in partitions should be framed in the same manner as outside door openings. Where there are corners, or where one partition wall joins another, corner posts or T-posts should be used to provide nailing surfaces for the interior wall finish. When the plans and specifications call for the installation of wall or insulating boards for interior side wall finish, you should place the studding



(1) Shed. (2) Gable.

Figure 13–22.—Types of roofs.

$1\frac{1}{3}$ feet apart. Then you'll have more nailing surface to keep the wall or insulating board from warping or buckling.

TYPES AND PITCH OF ROOFS

The SHED or SINGLE PITCH roof is for emergency construction, when sheds or additions to buildings are built. The pitch is in one direction only, as shown in figure 13–22 (1).

There are many types and combinations of roofs used

in frame construction. The primary object of a roof is to keep out the rain and the cold. It must be sloped so as to shed water and strong enough to withstand high winds. Roofs must be constructed more rigidly to bear the extra weight in areas where heavy snows fall. The most common roofs which you'll build are the NEAR-FLAT, the SINGLE PITCH or SHED ROOF, and the DOUBLE PITCH or GABLE roof. The HIP or VALLEY roof is very seldom used, particularly in advanced areas, since it is complicated and requires a lot of time and labor to construct.

The NEAR-FLAT roof is used where large buildings are framed under one roof. This type of roof is supported by means of trusses and it has a slight pitch or slope.

The DOUBLE PITCH or GABLE roof consists of a sloping surface on each side of the center line of the building which forms a ridge in the middle. You should be well acquainted with this type of roof (figure 13–22 (2)) as it may be used on any type of structure. Also, the gable roof is simple in design and economical. Therefore, it is the one most commonly used in naval construction. Before you get enough "know how" to construct, maintain and repair roofs, you'll need to be familiar with all the terms used in connection with roofs. These terms are:

1. The PITCH of a roof is the slope of the roof surface. It is the angle which the roof surface makes with a horizontal plane. The roof pitch is expressed by means of numbers, for example: 8 and 12—8, being the rise and 12, the run. On blueprints, the pitch is shown as in figure 13–23 (1).

2. The SPAN of any roof is the shortest distance between the two opposite rafter seats.

3. The TOTAL RISE is the vertical distance from the plate to the top of the ridge.

4. The TOTAL RUN refers to the level distance over which any rafter passes or ½ the span of the roof.

5. The UNIT OF RUN, or the UNIT OF MEASUREMENT, 1 foot or 12 inches, is the same for the roof as for any

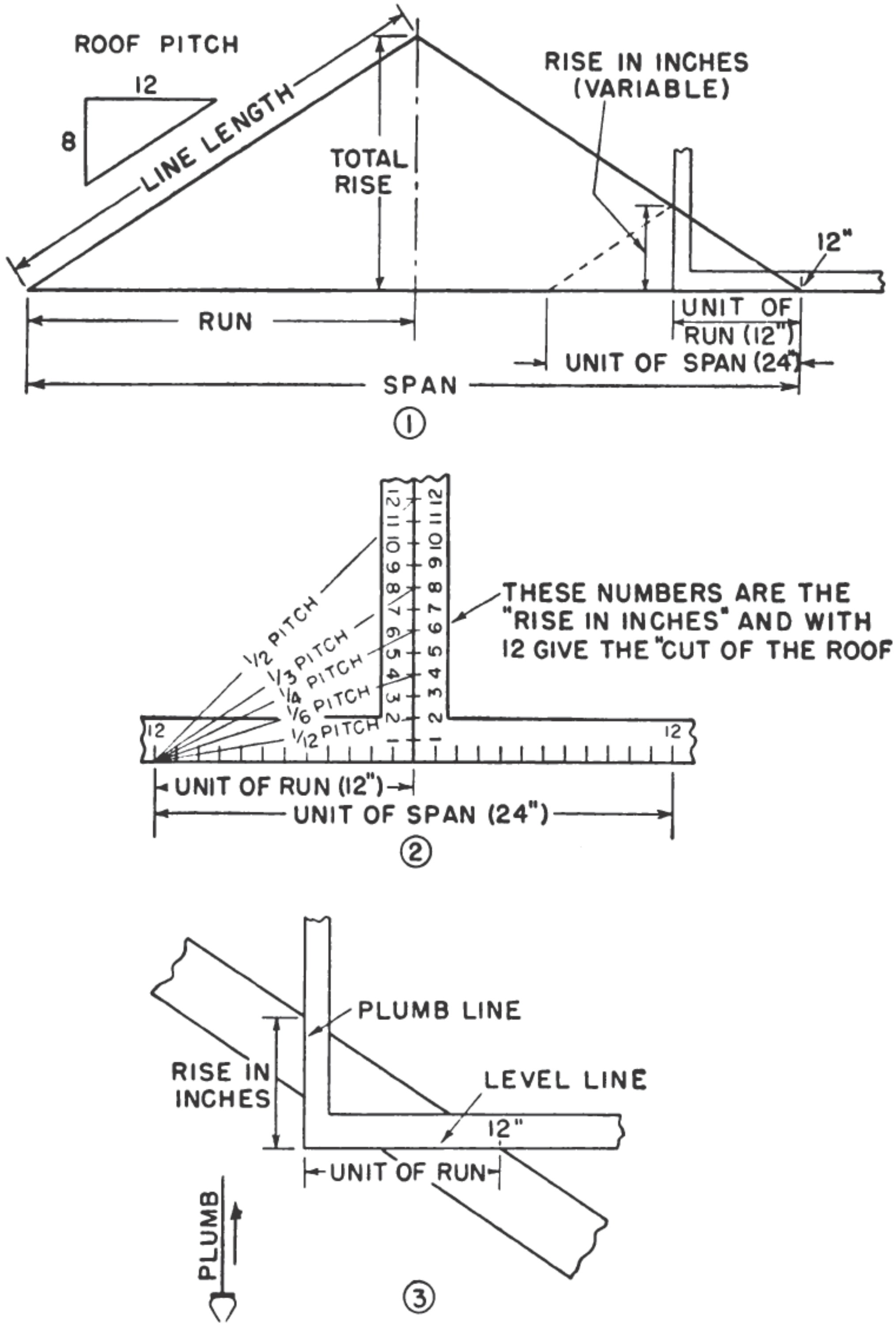


Figure 13–23.—Rafter layout.

part of the building. Using this common unit of measurement, you may employ the framing square in laying out roofs, as shown in figures 13–23 (1) and (2).

6. The RISE in inches is the number of inches that a roof rises for every foot of run.

7. The CUT OF A ROOF is the rise in inches and the unit of run (12) inches, as indicated in figure 13–23 (2).

8. The term LINE LENGTH, as applied to roof framing, is the hypotenuse of a right triangle, whose base is the total run and whose altitude is the total rise. (See figure 13–23 (2).)

9. The PLUMB and LEVEL LINES refer to the direction of a line and not to any particular rafter cut. Any line that is vertical when the rafter is in its proper position is called a plumb line. Any line that is level when the rafter is in its proper position is called a level line. Refer to figure 13–23 (3).

RAFTERS

The members which make up the main body of the framework of roofs are called rafters. They are inclined members, spaced from 16 to 24 inches apart, which rest at the bottom on the plate. They are fastened at the top

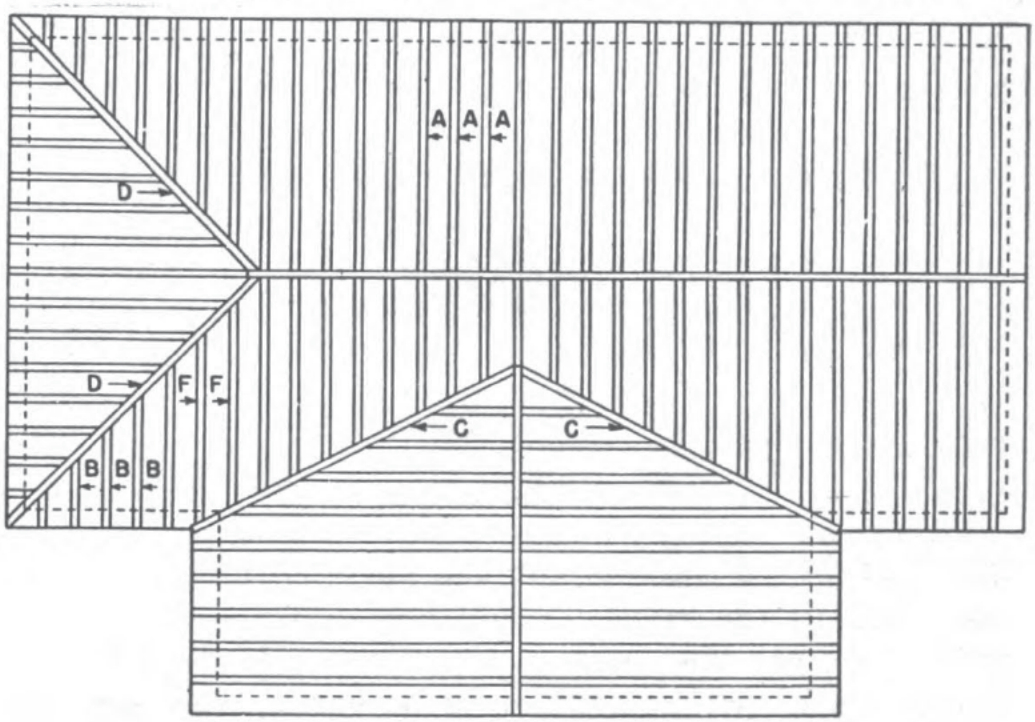


Figure 13–24.—Roof plan showing types of rafters.

in various ways, according to the form of the roof. The plate is actually a part of the wall and roof, serving as a connecting link between them. Rafters generally extend out a short distance from the wall to form the eaves which protect the sides of the building.

You'll use five different types of rafters in framing roofs. Observe the various kinds of rafters shown in

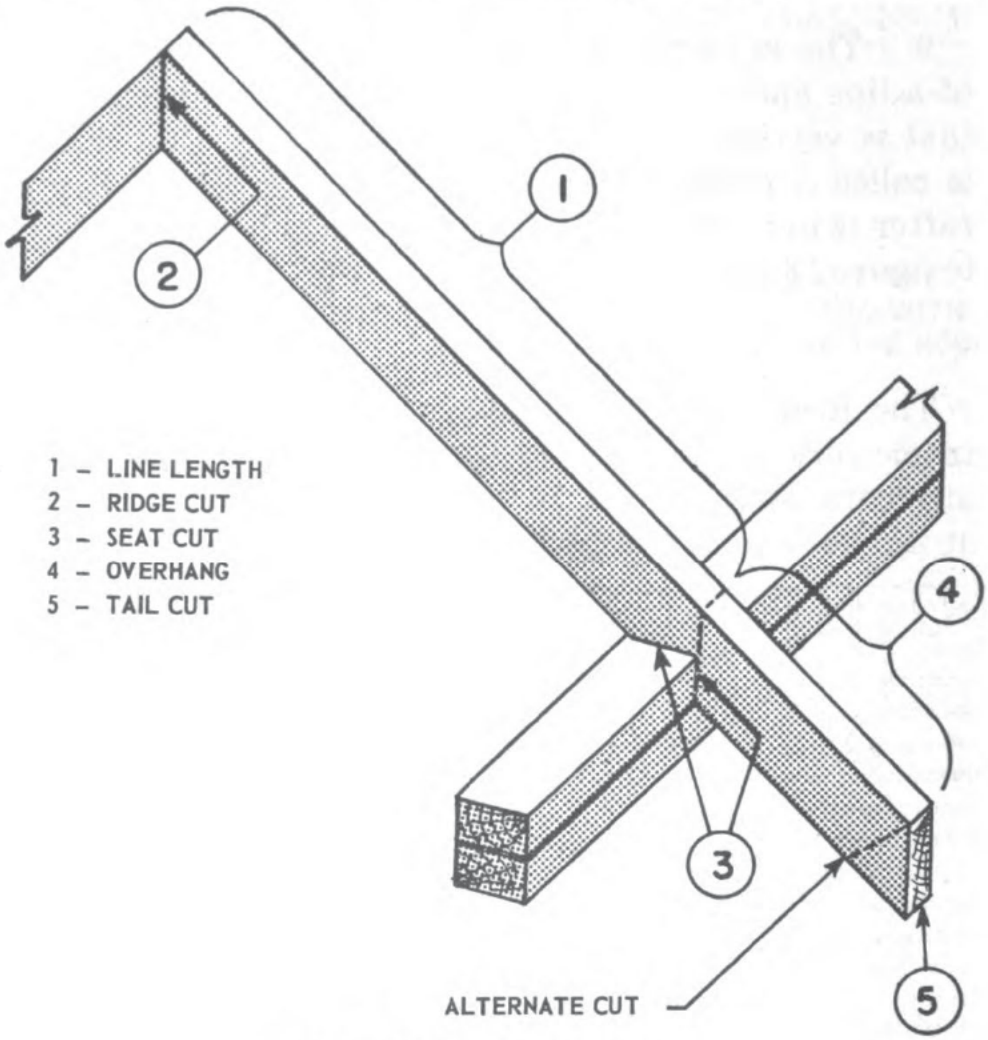


Figure 13-25.—Rafter terms.

figure 13–24. A's are the common rafters which run from the plate to the ridge. You'll see that these common rafters are not connected or crossed by any other rafter. B's are jack rafters and are shorter than the common rafters. Jack rafters do not extend from the plate to the

ridge, but are connected at one end to the hip rafter. C's are the valley rafters needed at every corner between the main building and a projection. D's are hip rafters. F's are the cripple rafters. They are so called because they have no bearing on the wall plate and do not extend to the ridge board.

You'll frame most roofs of wooden buildings, particularly in advanced areas, with the common rafters. However, in special types of buildings the others requiring more time and labor may be used. If you acquire the skill and knowledge necessary to lay out the common rafter, then you'll have little trouble laying out hip and valley rafters. The method of stepping off the lengths and cuts of hip or valley rafters is very similar to that of the common rafter. The unit of run of the hip or valley rafter is 17 inches. Remember, the unit of run of the common rafter is 12 inches. This greater unit of run is due to the angle at which the hip or valley rafter meets the ridgeboard and plate. The common rafter meets the ridgeboard and the plate at a 90° angle.

The terms commonly used in connection with rafters are as follows (see figure 13–25):

RIDGE CUT is the cut of a rafter that fits the opposite rafter at the ridge.

SEAT CUT is the notch which is cut in the rafter to fit on the plate.

OVERHANG is that part of the rafter that projects beyond the side of the building.

TAIL CUT is the cut on the lower end of the rafter.

LAYING OUT RAFTERS

You must lay out and cut rafters with slope, length, and overhang exactly right so that they will fit when placed in the position they are to occupy in the finished roof.

There are three methods which you may use to lay out rafters, namely:

1. Scale or measurement methods.
2. Step-off method.
3. Table method, using rafter table on framing square.

In the SCALE or MEASUREMENT methods, your first job is to determine the length of the rafter and the piece of lumber from which the rafter may be cut. If a set of the building plans, including the roof plan, is handy, you may get the rafter lengths and the width of the building from the roof plan. If no plans are available, then you may measure the width of the building with a tape.

In order to determine the rafter length, first find one-half of the distance between outer edges of the plates. You'll quickly see that this distance is the horizontal distance which the rafter will cover. Also, you must consider the amount of rise per foot. Assume that the building to be roofed is 20 feet wide and has an 8 inch rise per foot. Half the span will be 10 feet. To determine the approximate over-all length of the rafter, measure on the steel square the diagonal distance between 8 on the tongue and 12 on the blade, because 8 is the rise and 12 is the unit of run. You'll get a measurement of 14 5/12 inches, which represents the line length of a rafter with a total run of 1 foot and a rise of 8 inches. Since the run of the rafter is 10 feet, multiply 10 by the line length for 1 foot. You'll obtain an answer of 144 2/12 inches or 12 feet and 2/12 inches. If an overhang is used, which is often 1 foot, then you must add the amount of the overhang. Therefore, the total length of the rafter must be 13 feet. However, 13 feet is an odd length for stock lumber, so you'll select 14-foot pieces.

Having determined the length, you lay the material on sawhorses, with the crown or bow as the top side of the rafter. Always carefully select straight stock and the correct rough length for the pattern rafter. Hold the square with the tongue in the right hand, the blade in the left, the heel away from the body, and place the square as near the upper end of the rafter as possible. In this case, you place the figures 8 on the tongue and 12 on the blade of the steel square along the edge of the material which is to be the top edge of the rafter, as shown in

figure 13–26 (1). Mark along the tongue edge of the steel square, which will be the plumb cut at the ridge. Since you know that the length of the rafter is 12 feet, measure that distance from the top of the plumb cut and mark it on the material. Hold the square in the same manner, with the 8 marks of the tongue directly over the 12-foot mark. Mark along the tongue of the square to give the plumb cut for the seat, as shown in figure 13–26 (2). Then you measure off, perpendicular to this mark, the length

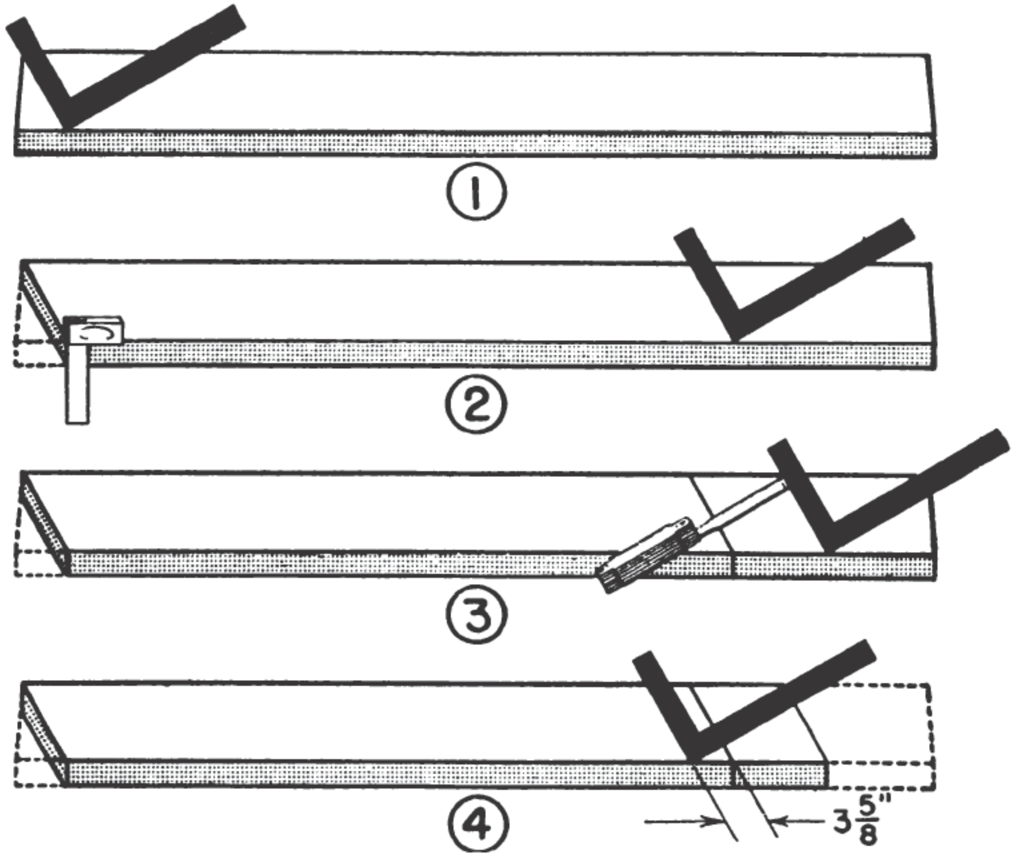


Figure 13–26.—Rafter lay out.

of overhang along the timber and make a plumb-cut mark in the same manner, keeping the square on the same edge of the timber, as shown in figure 13–26 (3). This will be the tail cut of the rafter; frequently the tail cut is made square across the material.

The level cut or width of the seat is the width of the plate, measured perpendicular to the plumb cut, as shown

in figure 13–26 (4). Using the try square, square lines down on the sides from all level and plumb-cut lines. (See figure 13–26 (4).) Now, you are ready to cut the rafter.

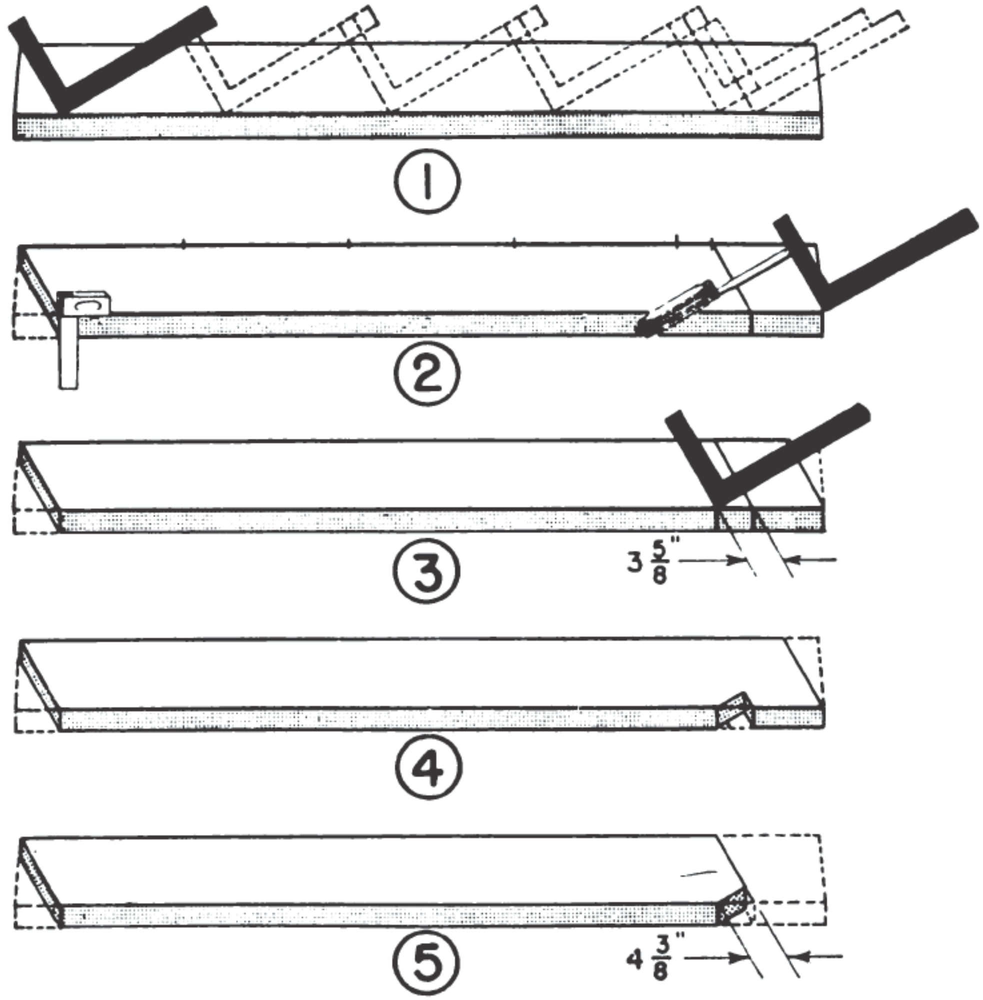


Figure 13–27.—Rafter lay out, step-off method.

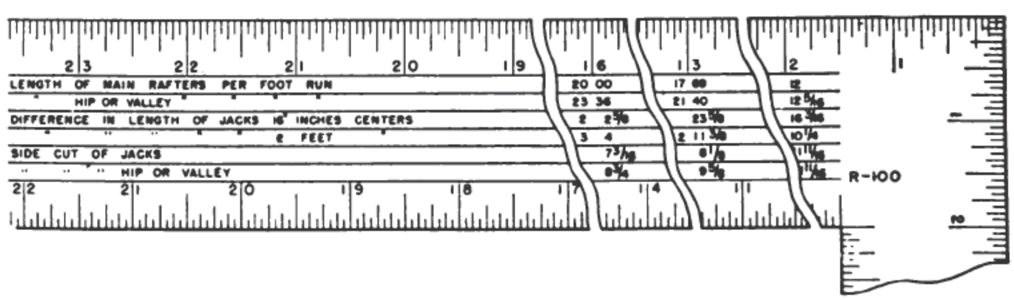


Figure 13–28.—Rafter table.

USING THE STEP-OFF METHOD

If the building is 20 feet 8 inches wide, the run of the rafter is 10 feet 4 inches, or half the span. You may also determine the rafter length by STEPPING IT OFF by successive steps with the square, as shown in figure 13–27. Stake the number of steps that there are feet in the run, which leaves 4 inches over a foot. This 4 inches is taken care of in the same manner as the full foot run; that is, with the square at the last step position. Make a mark on the rafters at the 4-inch mark on the blade, then move the square until the tongue of the square rests at the 4-inch mark. With the square held for the same cut as before, make a mark along the tongue. This is the line length of the rafter. Whenever you lay off rafters, by any method, be sure to recheck your work carefully. When two rafters have been cut, it is well to put them in place to see if they fit. You may then make minor adjustments without serious damage or waste of material.

HOW TO USE THE FRAMING SQUARE

The rafter tables on the blade of the framing square are shown in figure 13–28.

This type, as indicated, gives both the line length of any pitch or rafter per foot of run and the line length of any hip or valley rafter per foot of run. The difference in length of the jack rafter, spaced 16 or 24 inches (on center), is also shown in the table. Where the jack rafter, hip, or valley rafter requires side cuts, the cut is given in the table.

The table, as illustrated in figure 13–28, appears on the face of the blade. You use this table to determine the length of the common, valley, hip, and jack rafters, and the angles at which they must be cut to fit at the ridge and plate. In order to use the table, you must become familiar with it and know what each figure represents. The row of figures in the first line represents the length of common rafters per foot of run, as the title indicates

at the left-hand end of the blade. Each set of figures under each division mark represents the length of rafter per foot of run, with a rise corresponding to the number of inches over the number. For example, under the 16-inch mark appears the number 20.00 inches. This number equals the length of a rafter with a run of 12 inches and a rise of 16 inches. Under the 13-inch mark appears the number 17.69 inches, which is the rafter length for a 12-inch run and a 13-inch rise.

You must first know the width of the building so that you can use the framing square table for laying out rafters. Assume that the building is 20 feet 8 inches wide and the rise of the rafters is to be 8 inches per foot of run. The total run of the rafters will be 10 feet 4 inches. Referring to the first line of figures, under the 8-inch

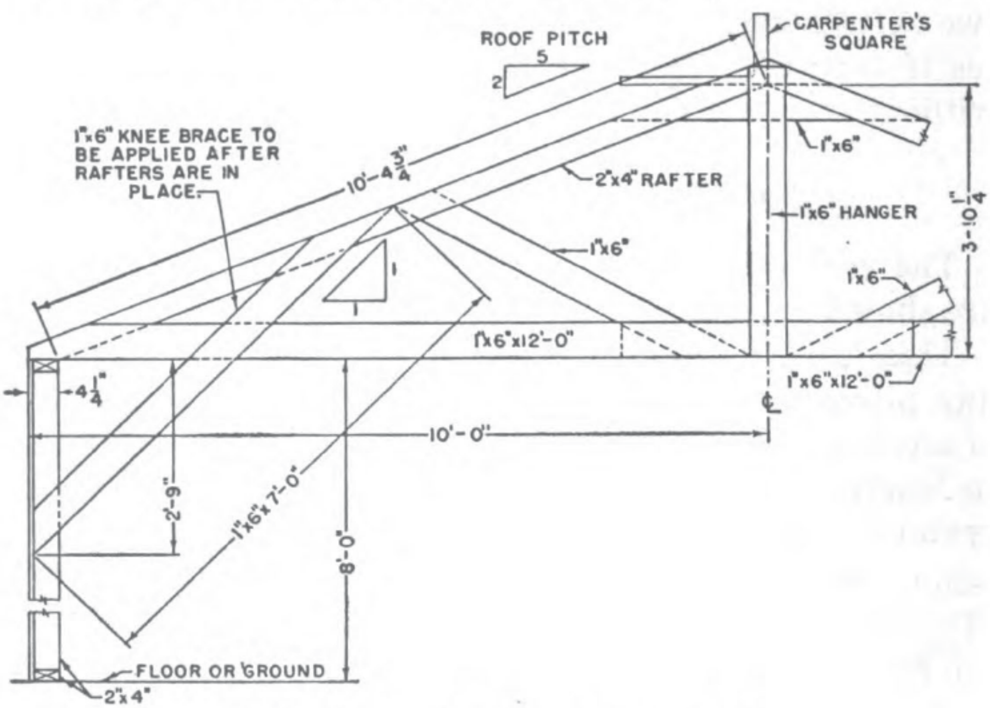


Figure 13-29.—Rafter construction detail.

mark, you'll see the number 14.42. This is the length, in inches, of a rafter with a run of 1 foot and a rise of 8 inches. To find the line length of a rafter with a total run of 10 feet 4 inches, you multiply 14.42 inches by $10\frac{1}{3}$ and divide by 12 to acquire the answer in feet.

$14.42 \text{ inches} \times 10\frac{1}{3} = 149.007 \text{ inches}$

$149.007 \text{ inches} \div 12 = 12\ 5/12 \text{ feet}$

Therefore, 12 feet 5 inches is the line length of the rafter. Then, with the steel square, lay off the ridge cut. Using the steel tape, your next step is to measure 12 feet 5 inches on the top edge of the selected material. You then mark the angles with the steel square as outlined in the scale or measurement method after you have found the length of the rafter with the use of the table on the framing square.

ERECTING RAFTERS

You'll seldom put up rafters singly. Usually, you will assemble them into trusses, as shown in figure 13–20. You connect two rafters at the top with a collar tie nailed into both rafters. Before you make fast any ties or chords, you should spread out the rafters at the lower end to correspond with the width of the building. This may be achieved by a template or by measuring the distance between the seat cuts. A chord or 2 x 6 is nailed across the rafters at the seat cut to tie them together. This chord forms a truss with the two rafters. A vertical member or 1 x 6 is nailed to the rafter joint and this extends to the chord at midpoint, thus securing the rafter to the chord. If you need no additional bracing, then you are ready to set the pair of rafters in place on the plates. If additional bracing is required, a knee brace is used. The knee brace should form an angle of 45° with the wall stud. Another brace is nailed to the rafter at its midpoint. This brace extends to the chord at its midpoint, as shown in figure 13–29.

In order to avoid hindrance in erection, the knee braces may be omitted until the rafter truss is set in place. After you have assembled the rafters into trusses, the next operation is placing the trusses on the building. Generally, you'll assemble the first set of rafters in the end section of the building. The rafter trusses are raised into position by hand and fastened to the plate with 16d or 20d

nails. These trusses should be temporarily braced to the end section of the building, until the roofing sheathing is applied. Knee braces should be installed before the sheathing or roof decking is applied. In general, good roof installation requires a solid deck of wood sheathing. Only when corrugated sheet metal or wood shingles are used is it advisable to have a slat-sheathed roof. You'll also sheathe roofs solidly for the installation of sheet metal where the climate is very cold. Wood sheathing is supported on rafters for sloping roofs and on joists for flat roofs. You should select well seasoned wood, 1-inch thick and from 4 to 8 inches wide. Roof sheathing should be secured with two or more 8- or 10-d nails. You should install all sheathing on the rafters in such a manner that all joints are made on the rafters and staggered in order to prevent a weak spot in the roof. When you are installing a solid roof decking, you may select sheathing that is square-edge, tongued-and-grooved, or shiplapped. After you have sheathed the roof solidly, your next step is to cut off the ends smoothly, leaving the correct amount of overhang. In cases where no overhang is required, then you should cut flush with the outside edge of the end rafters. Felt paper saturated with asphalt is then laid over the entire roof decking and made fast with roofing nails. All joints of the felt paper should be lapped and cemented with hot asphalt. The final roof covering of rolled roofing, or composition shingles, is installed over the felt paper. When wood shingles are used, the asphalt paper is omitted.

SAFETY PRECAUTIONS IN FRAMING

Always pull out nails in boards that have been used for temporary bracing.

Be sure that the frame is braced securely before you attempt to go out on it.

Make it a habit to sheathe sharp pointed tools before you attempt to carry them in your pocket.

Brace all frames securely at the close of each working

day. A temporary deck laid on the joists will provide you with a safe working platform. Likewise, a cat walk installed on the ceiling joists will enable you to work freely and safely while putting up the roof rafters.

Remember, also, to take down all ladders at the close of each day's work.

QUIZ

1. What are the basic members of the framing of a wooden building?
2. Name the four types of sills.
3. Why is a solid sill preferred to the laminated sill?
4. What are joists?
5. What is a common joist?
6. Why is the trimmer placed and made fast to the common joist?
7. Why are supports, known as bridging, installed?
8. Name the two kinds of bridging supports.
9. Where should bridging be placed?
10. Why should you lay all subflooring diagonal to the joists?
11. What are the three essential purposes of the top plate?
12. What is a sole plate?
13. Notched studs give the best bracing. What is this type of bracing called?
14. What is the pitch of a roof?
15. What is the span of any roof?
16. What is the plumb line?
17. What are five different types of rafters in framing roofs?

CHAPTER 14

PREFABRICATED STRUCTURES

THE LIGHTNING WAR

On 1 September 1939, a lightning war was launched in Europe. This type of warfare was tailor-made for American mechanical genius. Our war production record astounded the enemy—it even astounded us. The building of great quantities of planes, artillery weapons, ships, pontoons, motor vehicles, and military structures was done at a rate never before equaled. Out of this rapid mobilization of men and material came prefabricated structures to be used for camps and bases, both stateside and overseas. The most common of these was the Quonset hut.

ORIGIN AND HISTORY OF QUONSET BUILDINGS

In 1941, the Navy was confronted with the task of developing an all-purpose building for possible use on all the battlefronts of the world. Such a building had to be capable of functioning satisfactorily not only in the typhoon areas of the Pacific, but also in the heavy snow-

fall regions of the Arctic. Engineers, after much research, found that the most adaptable building shape was the semi-circular arch-rib type of structure. So the semi-cylindrical form of the Quonset hut was copied from the British Nissen hut.

The original Quonset hut was framed with arch rib members of steel. These members were covered with corrugated steel sheets supported by wood purlins. In a short time the engineers had considerably improved the Nissen type. A more suitable structural rib was found in the form of a welded steel member, 2 by $3\frac{5}{8}$ inches in size. This member—actually, two lightweight channels welded back to back—contained a groove which held nails. To reduce shipping space and tonnage, a building using light corrugated galvanized sheets for outside covering and half-inch plywood for floors was designed. The other principal improvements were an interior pressed-wood lining and insulation. The new hut was larger, 20 feet x 48 feet; and lighter, using $3\frac{1}{2}$ tons of steel instead of 4 tons. As finally developed, the Quonset hut required less shipping space than did tents with wooden floors and frames. Larger warehouse structures also were developed for Navy advanced base use. In all, 11,800 such warehouses were procured. For large advanced base supply functions, multiple arch unit warehouses were developed from the 40 x 100-foot warehouses to furnish greater storage area under single roofs.

The most important of the prefabricated buildings was developed at Quonset Point, Rhode Island. This accounts for its name—Quonset hut. More than 150,000 of these Quonset huts were used by the Navy to meet its needs during World War II. These buildings were used for almost any purpose that you can think of—from the housing of men to the storing of supplies and equipment.

IMPORTANT SUGGESTIONS

You'll find that rapid erection of the arch-rib hut is easy. One operation quickly follows another—if the first

one is done properly. It is most important to get off to a good start. Be sure that the floor joist assembly is level and square. Make sure that the rib assembly is plumb. Then you can proceed with the later operations without difficulty. The five essential operations in erecting the 20′ x 48′ hut are: (1) leveling the site, (2) setting the frame, (3) applying flooring, inside covering, and insulation, (4) applying ventilators and roofing, and (5) setting bulkheads.

If you find that any of the steel members have been bent in shipment, ask one of your shipmates to bear a hand. Place the bent part over a crate or sawhorse. Then you and your shipmate bear down on each end until the member is straight. You'll discover that the hardest way to straighten a member is by using a hammer.

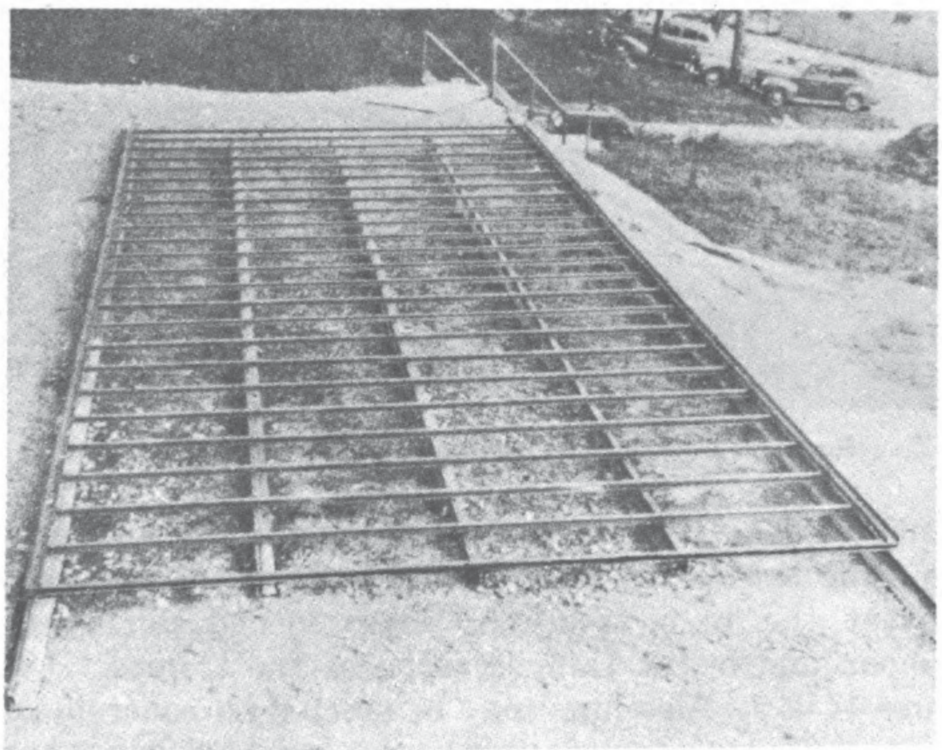
There's also a trick to opening the banded crates. Acquire this "know how" and use it. You'll save yourself a lot of time and effort. Take one of the screwdrivers furnished for assembling the frame. Insert the flat side under steel band, binding the crate, about an inch or an inch and a half. Turn the screwdriver about an eighth of a turn or until you bring the sharp edge of the screwdriver shank into contact with the steel band, and then pull up quickly. This motion cuts the band instead of breaking it. When you have acquired the knack of using the screwdriver, opening crates is an easy job.

It is very important that you use the right nails, screws, and attachments. You must follow instructions closely. If the wrong hardware is used, it will mean borrowing from huts all down the line.

A complete set of tools is furnished for erecting the hut. There is one set for every four huts. If you are erecting many huts at one location, the best scheme is to open all the boxes containing tools and pool them. Then, you may issue them to your shipmates as they are needed. Be sure to take proper care of the tools provided. You'll need them.

LAYING THE FLOOR FRAMING OF THE 20' x 48'

You'll see that the 20′ x 48′ arch-rib hut is equipped with 2- to 4-foot overhangs. The first hut discussed here is of tropical design. The overhangs are installed to prevent heavy rain and sunlight from entering the hut through the end bulkheads. The 4-foot overhangs are unnecessary in northern or temperate climates. The nomenclature for both the northern and the tropical type hut is based on the interior living dimensions. Therefore, with few exceptions, when you speak of Quonsets, you'll be referring to the 20 x 48-foot living space size.



Courtesy of Great Lakes Steel Corporation.

Figure 14–1.—Complete floor frame.

The floor joist assembly of the 20′ x 48′ Quonset consists of steel sills, joists, and channel plates. The sills run lengthwise and support the joists, which are fastened to the sills at right angles. At the extreme ends of the

joists, channel plates are fastened for receiving the ribs. (See figure 14–1.)

The first operation is to level and tamp an area of ground 30′ x 60′ for the hut site. If the site is too uneven to level easily, the hut may be leveled by setting it on wooden posts. In tropical areas, huts are assembled on wooden foundation posts. These posts should be of suffi-

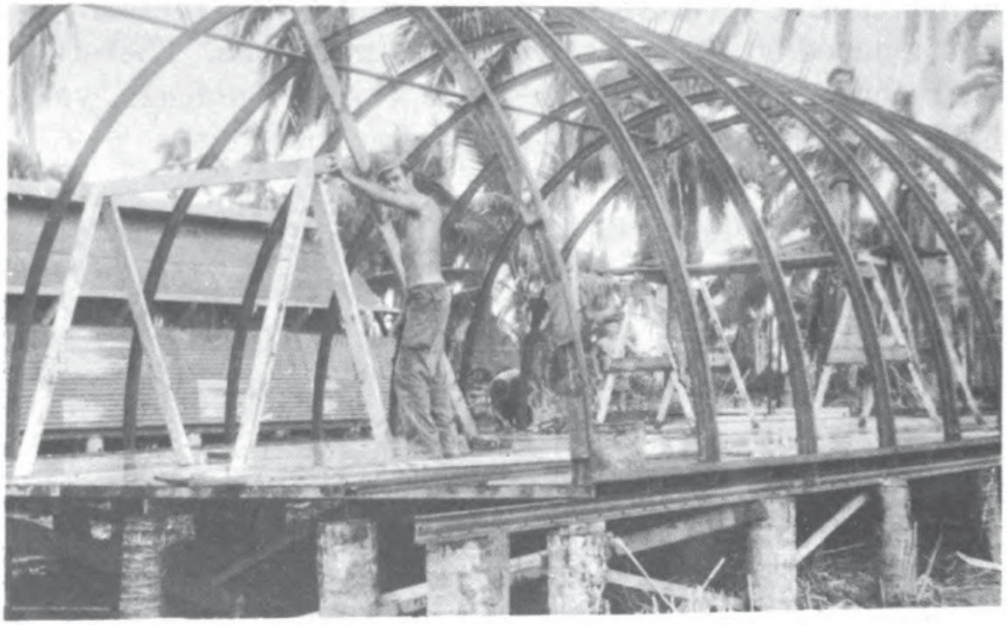


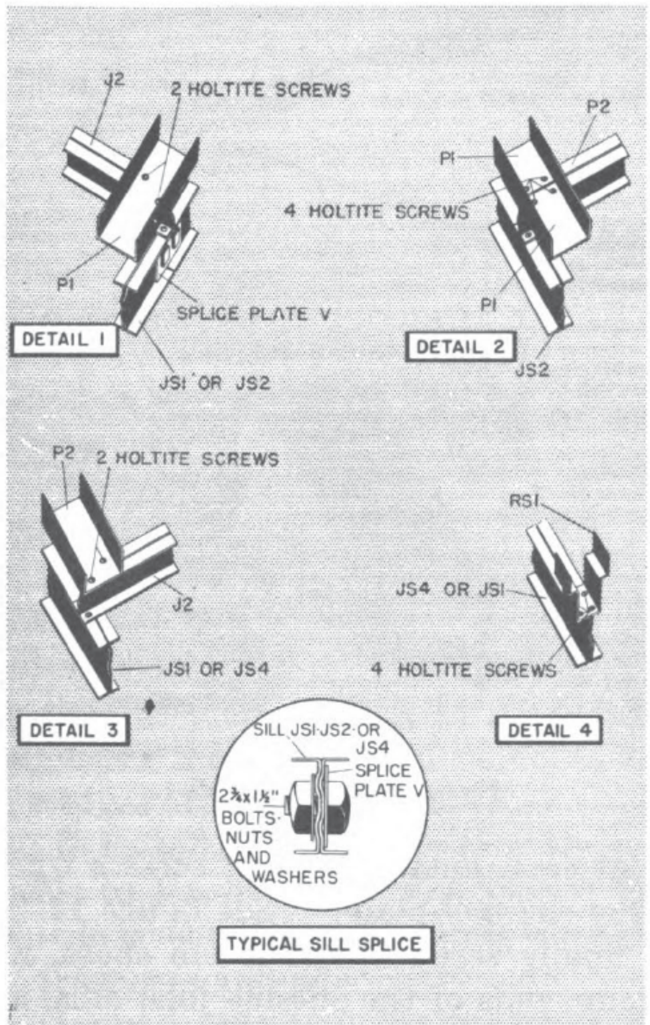
Figure 14–2.—A Quonset hut supported by foundation posts.

cient length to give about 3′ of bearing in the soil and at the same time extend high enough above the ground to prevent the huts from becoming flooded during the typhoon and heavy rainy seasons of the tropics. (See figure 14–2.) Also huts may be erected on concrete columns or piers.

Materials for foundation work are not furnished in the assembly crates. You may use the trees near your erection location as material to make the foundation posts.

Assuming that you have been able to level and tamp the required area of ground for the hut site, your second operation is to lay the sills on the tamped ground in five parallel lines about 5′ apart. Be sure that the holes for connecting the joists are facing upward. The end sills

marked JS–4 and JS–1 have 4 holes in one end. Place the 4-hole end to the outside of the hut. Then, line up the sills with the nailing groove curves matching, as indicated in figure 14–3. Be sure to match these nailing groove



Courtesy of Great Lakes Steel Corporation.

Figure 14–3.—Typical sill splice.

curves. If you don't, the sills will be forced out of line when you tighten the splice plate.

The third step is to lay the joists, connecting holes down, at right angles to the sills on 2′ centers, as shown in figure 14–4. Use a drift pin to line up the holes and insert 2 screws diagonally opposite each other at each connection. At each splice in the sills use 4 screws.

The fourth operation is to place the channel plates marked P-1 and P-2 over ends of joists and parallel to outside sill joists. Screw these to the joists. Use 2 screws

Courtesy of Great Lakes Steel Corporati

Figure 14–4.—Sill and joists.

Courtesy of Great Lakes Steel Corporation.

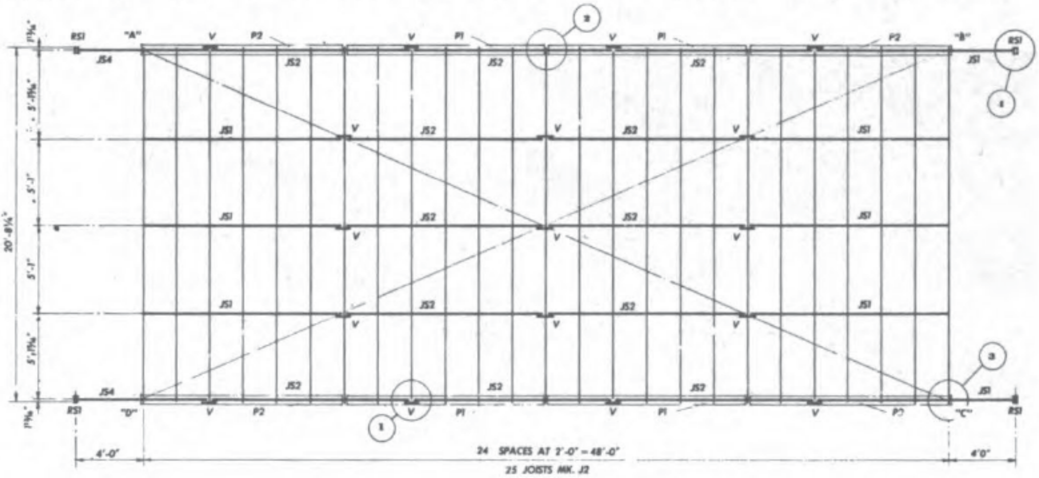
Figure 14–5.—Attach RS–1.

diagonally at each joist, but use 4 screws where there is a joint in the channel plate. (See figure 14–3, detail 2.) Then, you finally screw the four rib shoes, marked RS, to the extreme ends of the outside joist sills, as shown in figure 14–5 and detail 4 of figure 14–3.

The fifth step in laying the floor framing is to square up the floor assembly. Figure 14–6 illustrates the floor framing plan.

The distance AC must be the same as BD. You should use the roll of wire from the tool box for measuring these distances. Hold one end of the wire on the inside lip of the channel plate A. String the wire to the same point at C. Do the same from B to D. Then shift the corners until distances AC and BD are equal. Check the ends and

sides for straightness, using a line or wire, and recheck for square. Check the assembly for level starting at joist BC. With this joist level, proceed to level the channel plate, working from C to D. Level the channel plate by placing the level on the lip of the plate in about four



Courtesy of Great Lakes Steel Corporation.

Figure 14–6.—Floor framing plan.

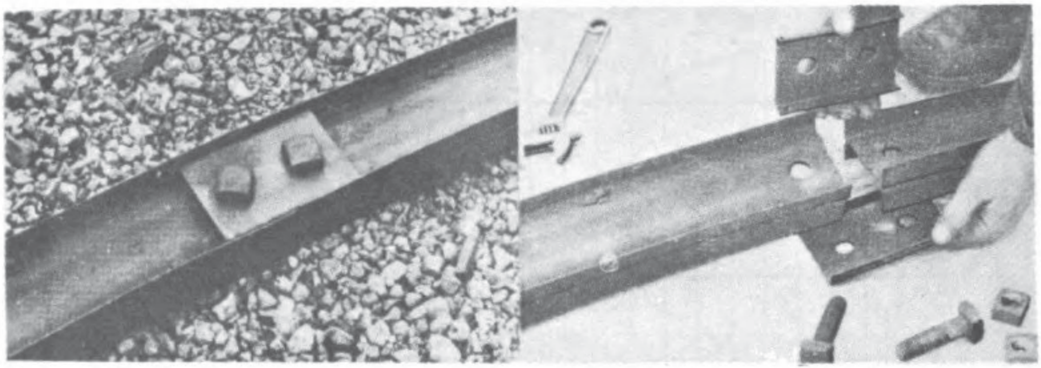
locations. When the channel plate is leveled, level the other end joist, working from D to A. Then proceed with leveling the channel plate from A to B. Bring the other joists to level, using the level at four points as for opposite side. Small wedges or blocking made from crating lumber may be used to raise the sills. You may scoop dirt from under the sills to lower them. You should be sure the floor assembly is level before proceeding with the installation of ribs, trimmers and purlins.

INSTALLING RIBS, TRIMMERS AND PURLINS OF THE 20' x 48'

The rib assembly consists of two steel sections or half-ribs which are joined together at the top with splice plates marked B. The lower ends of the ribs are secured to channel plate. In the case of the end ribs, the lower ends of the ribs are secured to a rib shoe marked RS 1. The three rows of purlins are supported on purlin spacers marked PS 2. Two rows of trimmers, marked T-48 are fastened to lower flanges of the ribs. You can construct

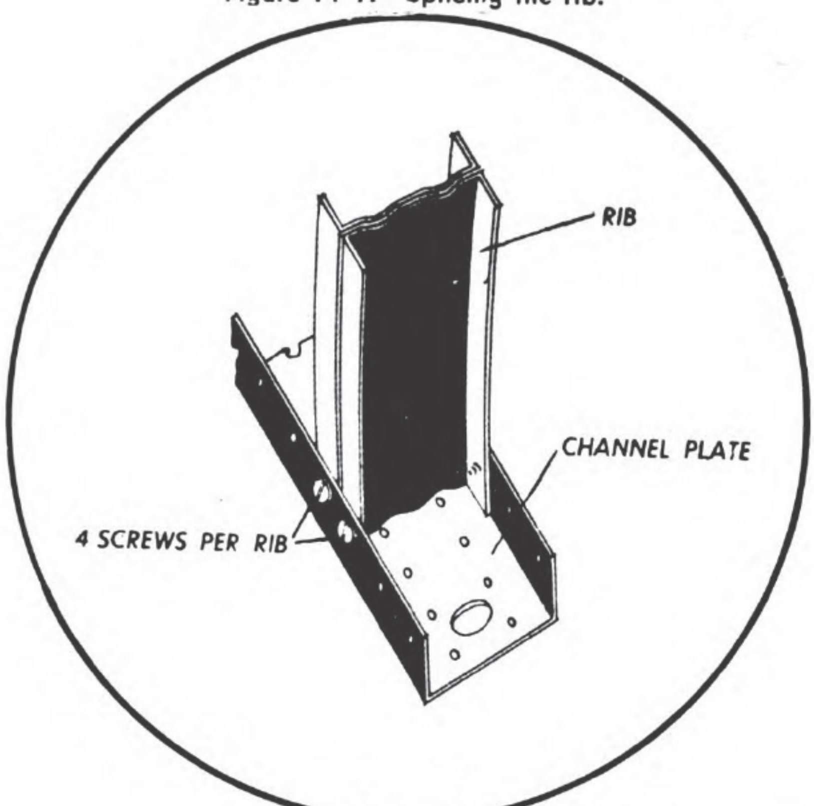
a scaffold from crating lumber to use in making trimmer and purlin connections at the top of the rib.

Your first step consists of assembling all the ribs on the ground before raising any. Ribs should be joined at the top with two splice plates marked B and two $\frac{3}{4}$" x $2\frac{1}{2}$" bolts. (See figure 14–7.) Then you attach



Courtesy of Great Lakes Steel Corporation.

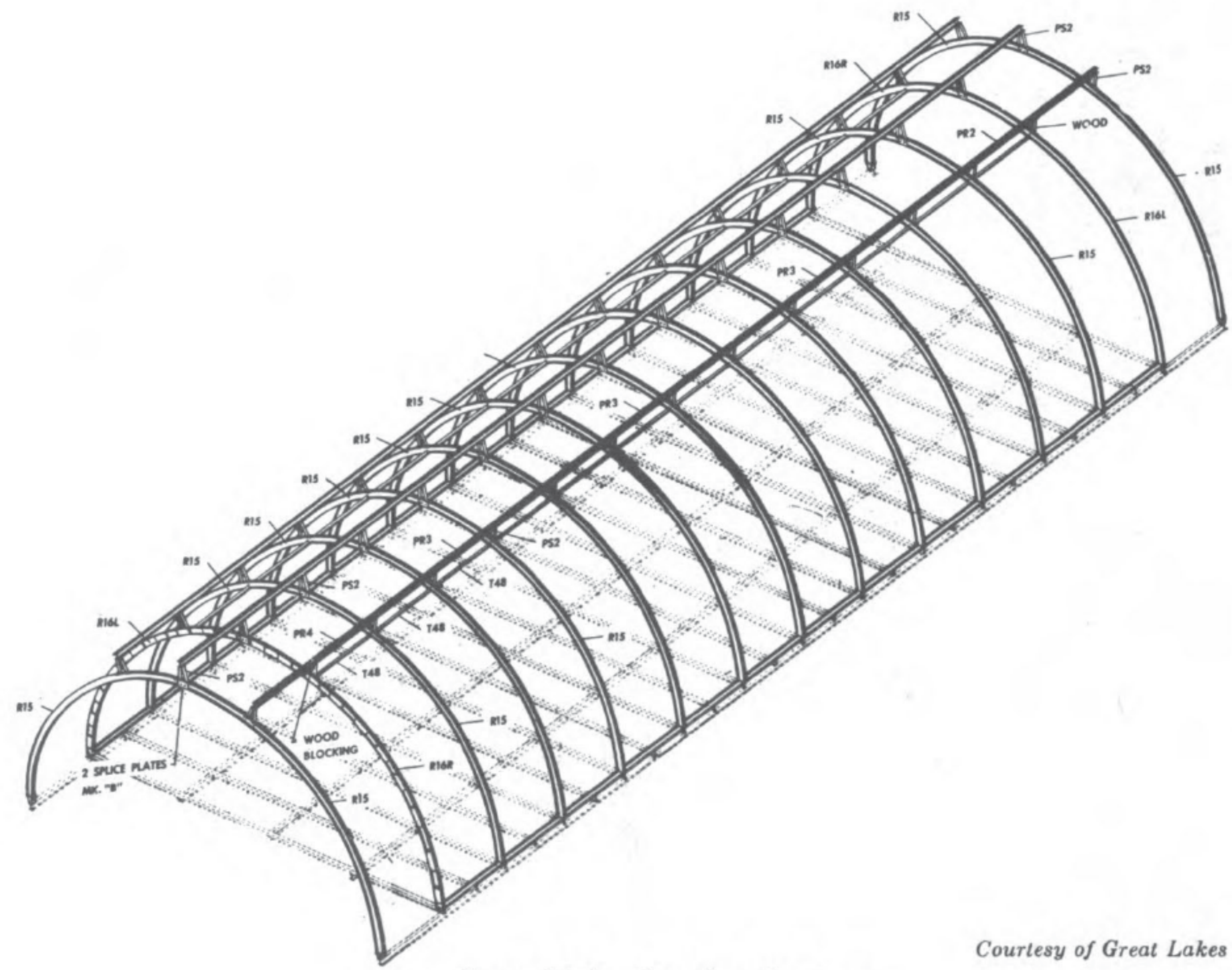
Figure 14–7.—Splicing the rib.



Courtesy of Great Lakes Steel Corporation.

Figure 14–8.—Detail at plate.

purlin spacers PS 2 while ribs are on the ground. In assembling the ribs with wood blocking, you should take



Courtesy of Great Lakes Steel Corporation.

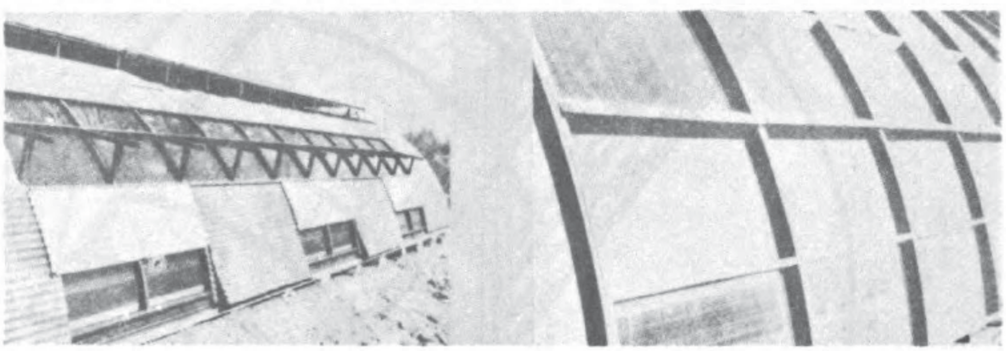
Figure 14–9.—Complete framing.

care to have the bolt head on the block side of the rib, so that the latter work will clear. The ribs with the wood blocking will be the second from each end and the blocking side should face outward. Raise one of these ribs first and secure it to the channel plate with four Holtite screws (see figure 14–8).

The second operation is to fasten the trimmers to the next rib while it is on the ground. Raise this rib, fasten the trimmers to the rib already raised, and secure the rib to the channel plate. Repeat this operation for each successive rib. Since end ribs have no trimmers, do not raise them until purlins are in place.

The third step is to fasten the purlins in place after the ribs are raised, using screws.

After the ribs with trimmers attached have been erected and the framing completed (see figure 14–9), your final and fourth operation is to recheck the entire structure to make certain it is plumb. Now you are ready to install the steel framing for canopy, and the wood sills and headers for screened openings.



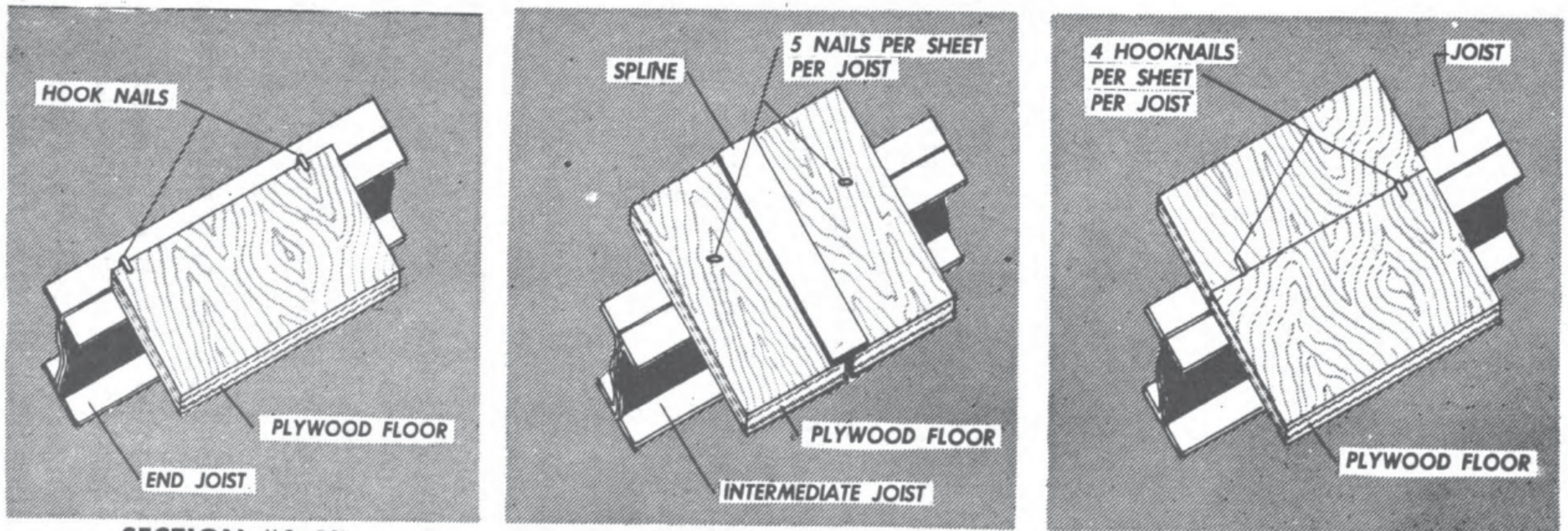
Courtesy of Great Lakes Steel Corporation.

Figure 14–10.—Canopy framing, wood sills, and headers.

CANOPY FRAMING, WOOD SILLS, AND HEADERS OF THE 20′ x 48′

The steel framing for the canopy consists of stud section rafters and channel section struts as shown in figure 14–10.

Your first step is to fasten these members together with



SECTION "A-A"

SECTION "B-B"

SECTION "C-C"

Courtesy of Great Lakes Steel Corporation.

Figure 14–11.—Floor panels.

screws before securing them to the ribs. You should not fasten strut CF 2 to ribs until corrugated sheets are applied at the end bends.

Your second and last operation is to nail wood sills and headers in place through holes provided in ribs for this purpose. Start with the header for the lower screened opening, then the sill above, and then move on to the header at canopied opening.

INSTALLING FLOOR PANELS OF THE 20' x 48'

The floor consists of 4′ x 8′ plywood panels nailed to the floor joists. Metal splines fit between the lengthwise joints. The installation of the floor panels consists of two operations, namely:

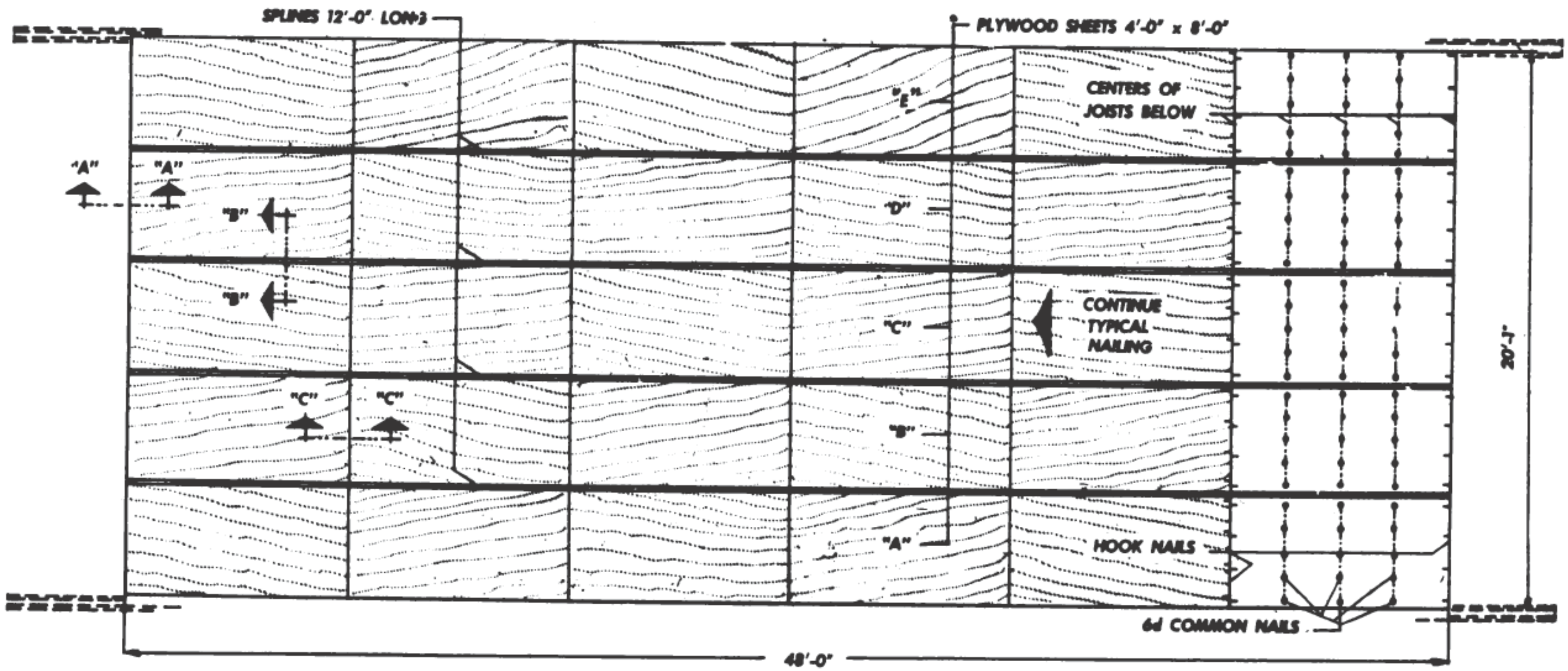
1. You should lay out all the plywood panels, clear side up, starting with row A. Then, proceeding to rows B, C, D, and E, fit the metal splines between the rows as each is laid. (See section B-B of figure 14–11.) The ends of the panels should butt over the center of joists Nos. 5, 9, 13, 17, 21, and 25.

2. The panels are then nailed in place using 6d, common nails at intermediate joists (see section B-B of figure 14–11), and hook nails at the ends of the panels as shown in section A-A and C-C of figure 14–11. To establish a nailing line for the intermediate rows of nails, hold each end of a chalk line over the center of the joist; pull the line taut and snap. This will leave you a guide line on the panel. You should use only the quantity of nails the sketches call for. Figure 14–12 illustrates the layout of plywood panels.

Figure 14–13 shows you how to install floor panels and a completed floor.

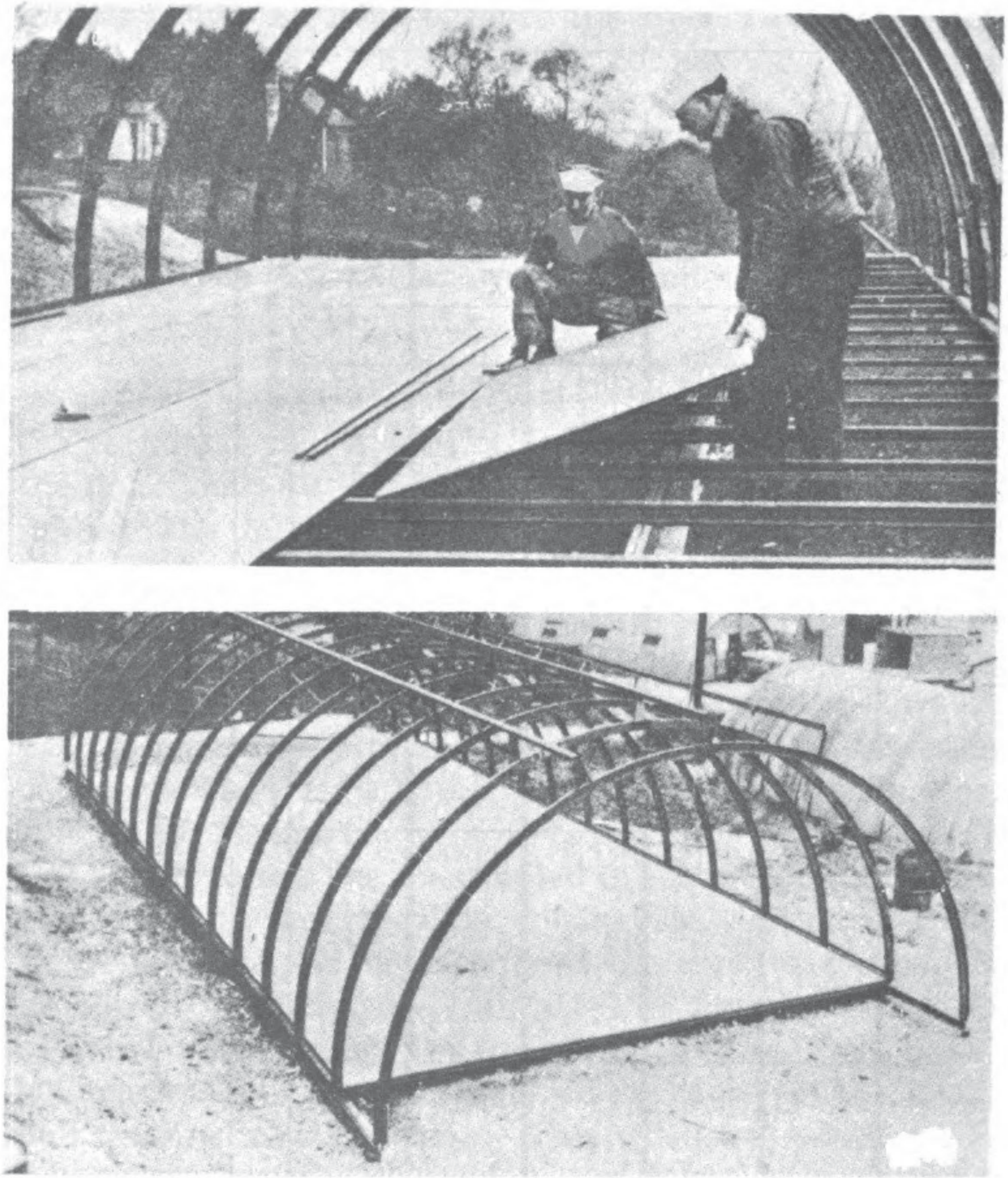
INTERIOR COVERING AND SCREENED OPENINGS

When the plywood floor panels have been laid, the next installation is the interior ceiling, side wall coverings, and the screened openings. The wall-board sheets are placed at the raised ceiling first, then on the side walls. Filler



Courtesy of Great Lakes Steel Corporation.

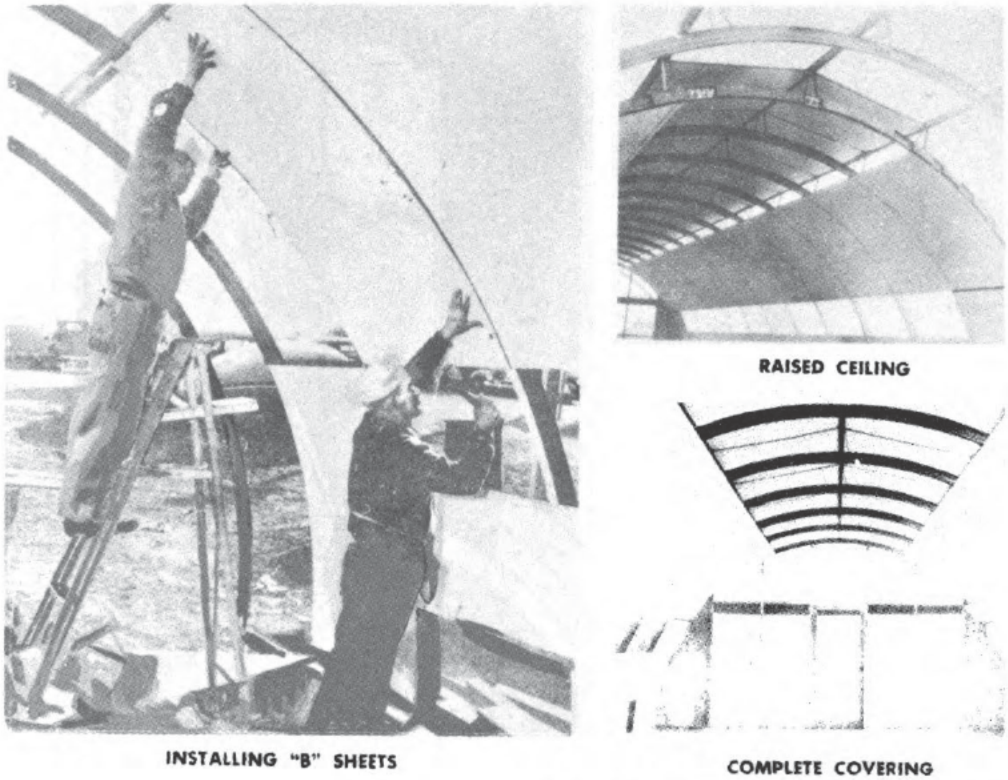
Figure 14–12.—Layout of plywood panels.



Courtesy of Great Lakes Steel Corporation.

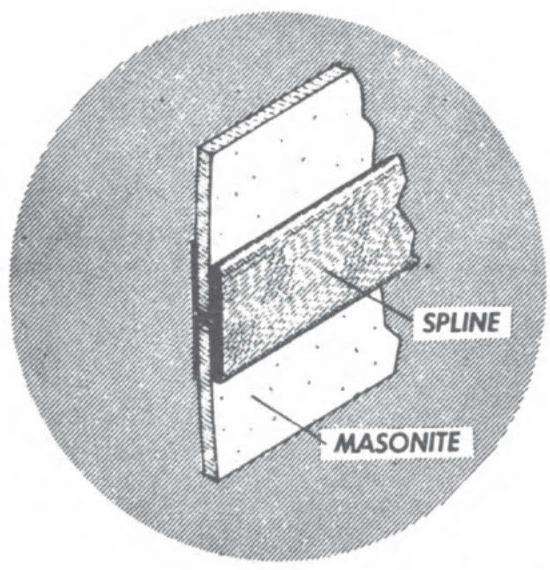
Figure 14–13.—Applying floor panels. Completed floor.

strips should be fastened where ribs are exposed at screened openings. The interior of the hut is covered with sheets of finished wall-board, generally $\frac{1}{8}''$ masonite. Wall-board is made fast to the ribs or supported on purlins, with the smooth side facing inside the hut. Figure 14–14 illustrates the method used for installing "B" sheets as indicated by A, raised ceiling B, and complete covering C. You have four steps to consider in



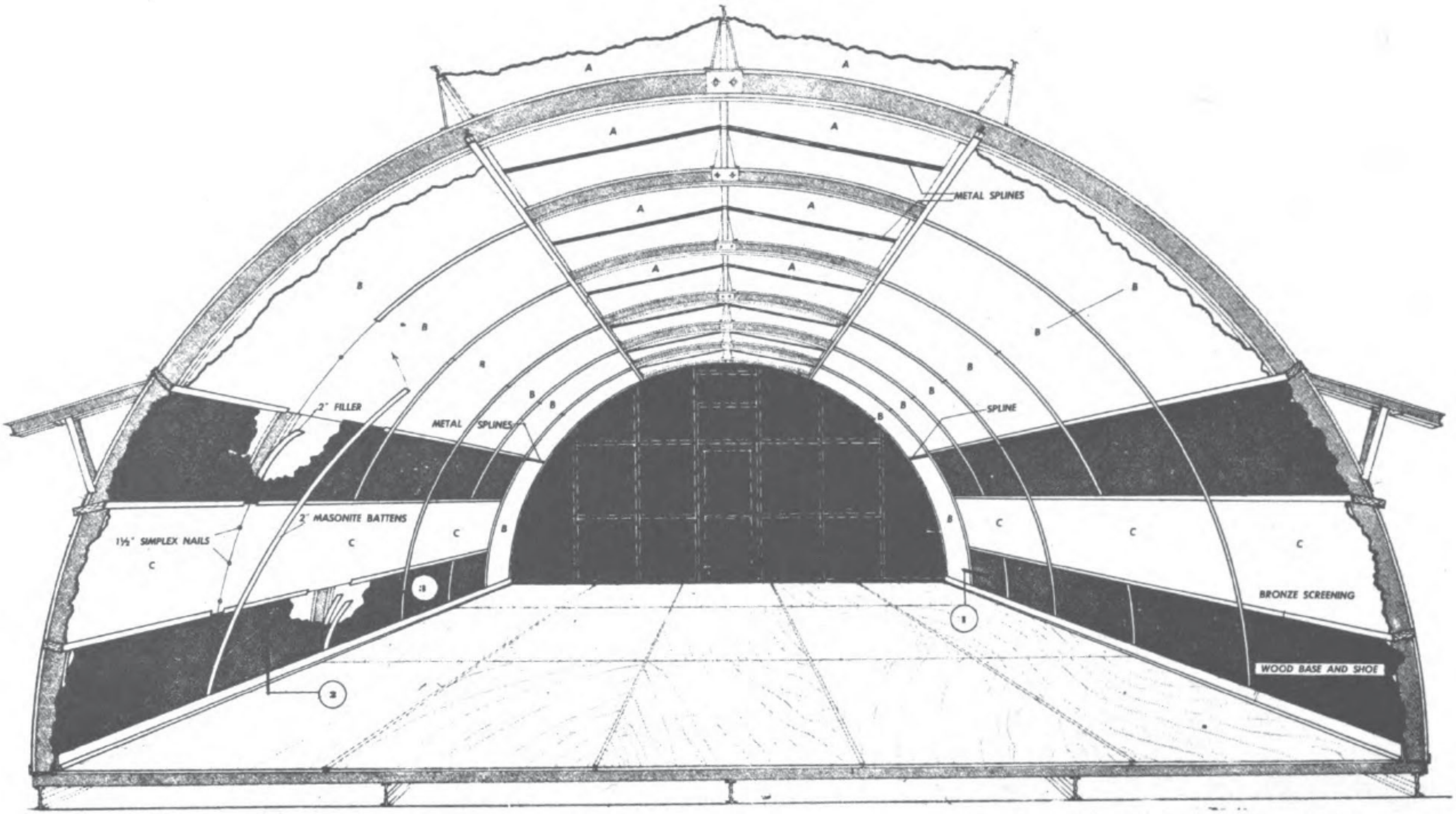
Courtesy of Great Lakes Steel Corporation.

Figure 14–14.—Interior covering.



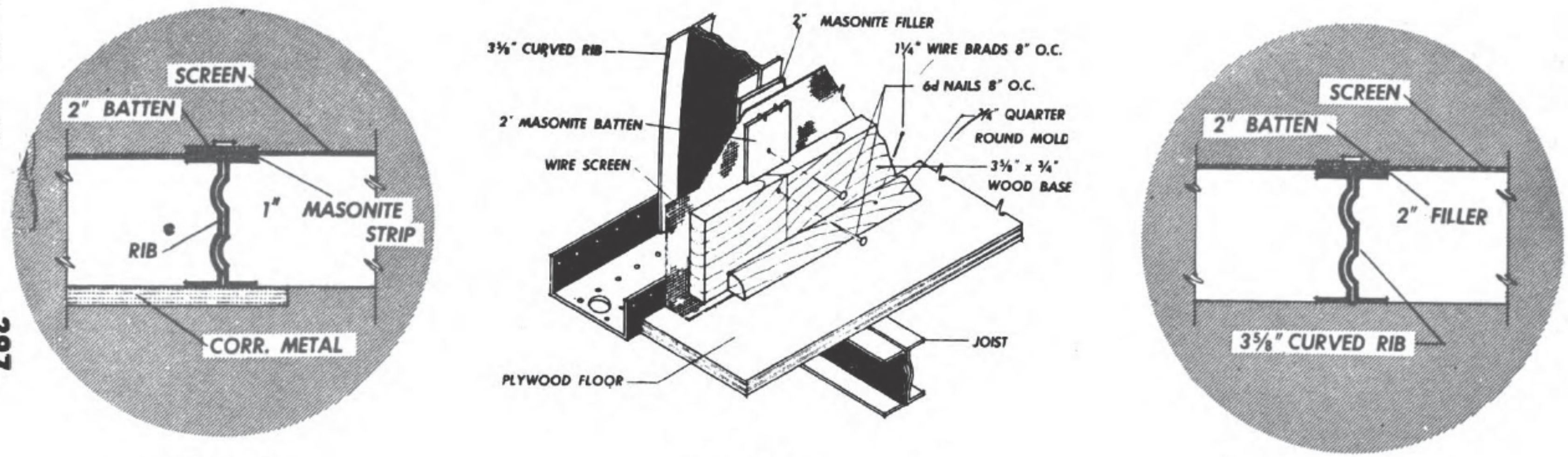
Courtesy of Great Lakes Steel Corporation.

Figure 14–15.—Metal spline.



Courtesy of Great Lakes Steel Corporation.

Figure 14–16.—Cut away view.



DETAIL 1 DETAIL 2 DETAIL 3

Courtesy of Great Lakes Steel Corporation.

Figure 14–17.—Fastening 2" wall-board batten strips.

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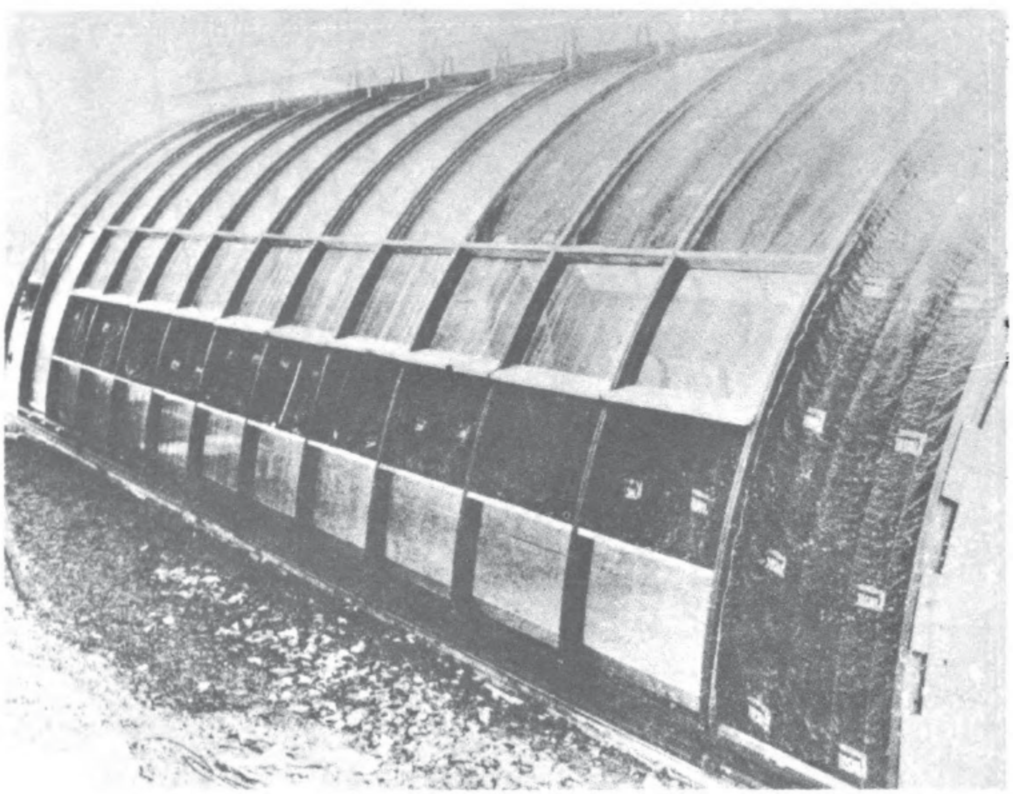
the installation of the interior covering and screened openings:

1. You should place the twenty-four "A" sheets (3′ 11⅞″ x 4′ 0″) on the bottom flanges of purlins, with metal splines between the sheets as indicated in figure 14–15.

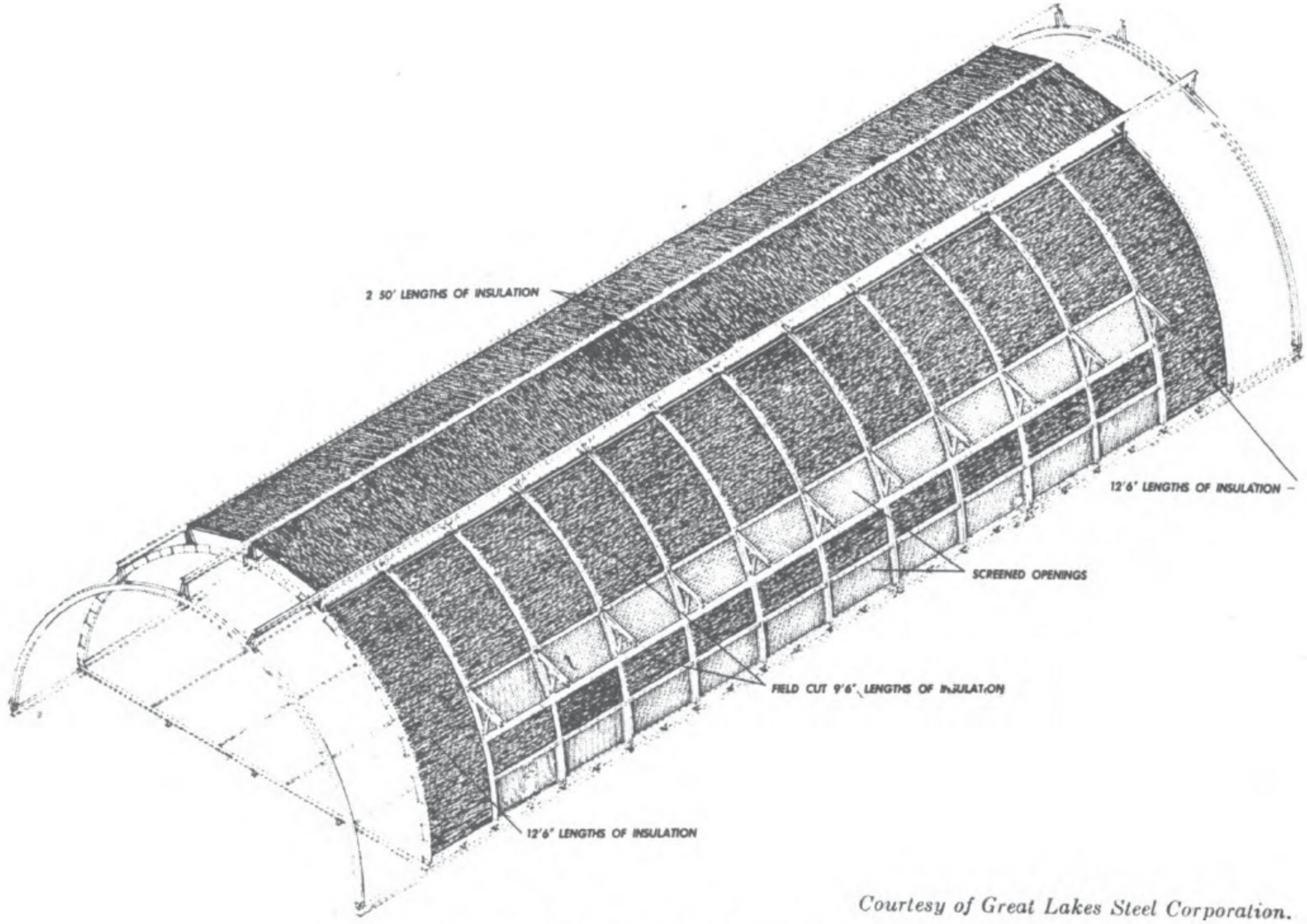
2. Check the ribs to see that they are plumb and true, and measure 4′ center to center. Fasten the twenty-eight "B" sheets (3′ 11⅞″ x 6′) to the ribs and wood headers, starting with lowest sheets at end bays. You should space the nails as required to hold sheets snugly against the ribs. **Notice in figure 14–16 that there is a metal spline between the upper and lower "B" sheets at ends of the hut.**

3. Secure ten "C" sheets (2′ 3″ x 7′ 11⅞″) to wood sills and headers with 6d common nails, and to ribs with the special nails furnished. You should fasten wall-



Courtesy of Great Lakes Steel Corporation.

Figure 14–18.—Installing insulation.



Courtesy of Great Lakes Steel Corporation.

Figure 14–19.—Insulation in place.

board filler strips where ribs are exposed at screened openings.

4. You then cover the openings with bronze screening. Install the wood base and shoe. Fasten 2″ wall-board batten strips over all ribs and around screened openings with 6d nails as shown in detail 1, 2, and 3 of figure 14–17.

INSULATION OF 20′ x 48′

Insulation of the hut is the next step, after you have installed the interior covering and screened openings. Always apply the insulation to the raised ceiling area first. Then apply it above and below the canopied opening, and finally in the end bays. See figure 14–18.

Flexible-type insulation 4′ wide is laid over the wall-board inside covering and between the ribs of the hut. You'll find that most of this insulation is pre-cut to size, with the exception of the twenty 9′6″ lengths. These lengths must be re-cut as you apply the insulation.

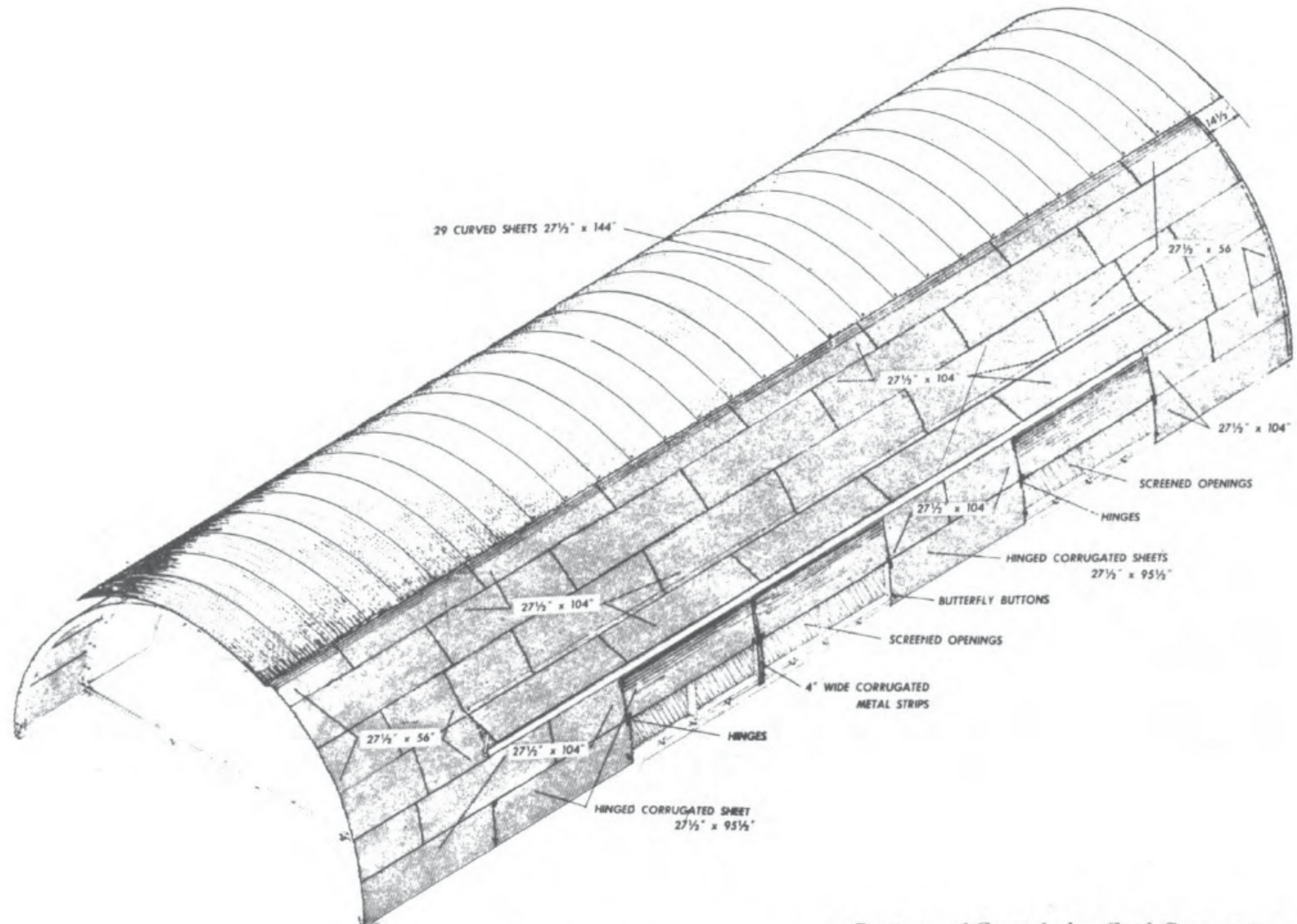
Your first step is to lay the two 50′ lengths of insulation on the wall-board ceiling sheets "A" as indicated in figure 14–19.

2. The next step is to secure the four 12′ 6″ lengths, two in each end bay as shown in figure 14–19.

3. The last step is to cut each of the twenty 9′ 6″ lengths into two pieces, 6′ 6″ and 3′ long. These cut pieces should be placed above and below the canopied opening. You then nail the insulation to wood sills and headers. The insulation is secured to trimmers at the top with crating lumber battens and clinch nails.

INSTALLING THE EXTERIOR COVERING

The exterior covering of the 20′ x 48′ consists of covering the sidewalls with flat corrugated sheets, including the hinged ventilator flaps and canopy. You fasten bronze screening and flashings F6 and F7 at raised roof. Also, you secure the curved corrugated sheets to purlins. On the sides, the flat sheets are fastened to the ribs and



Courtesy of Great Lakes Steel Corporation.

Figure 14–20.—Layout of corrugated sheets.

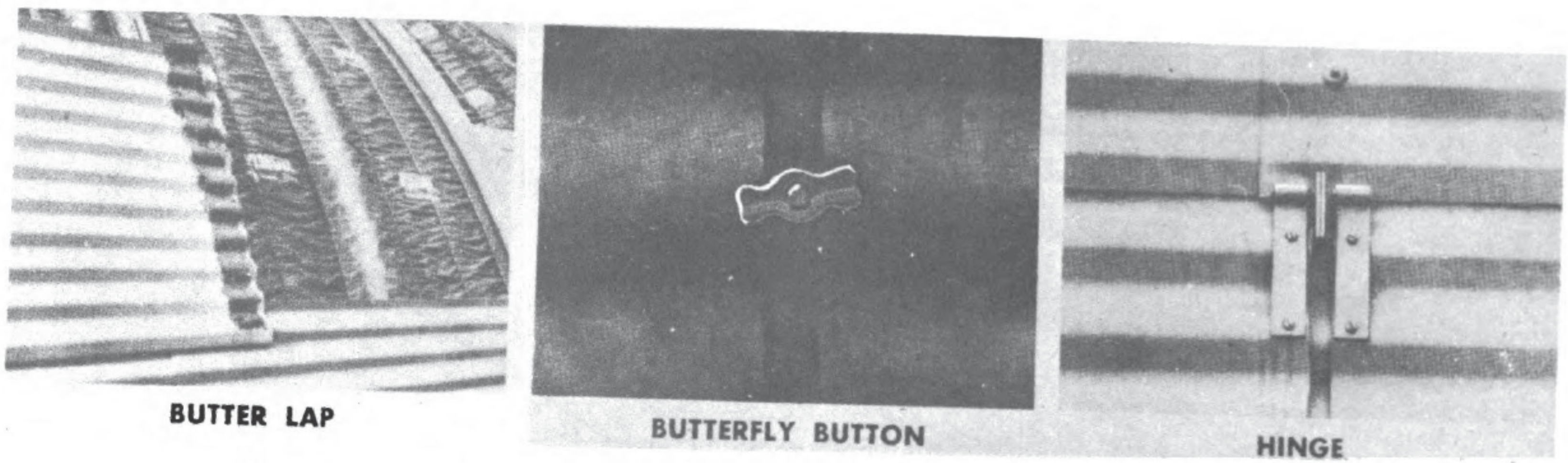
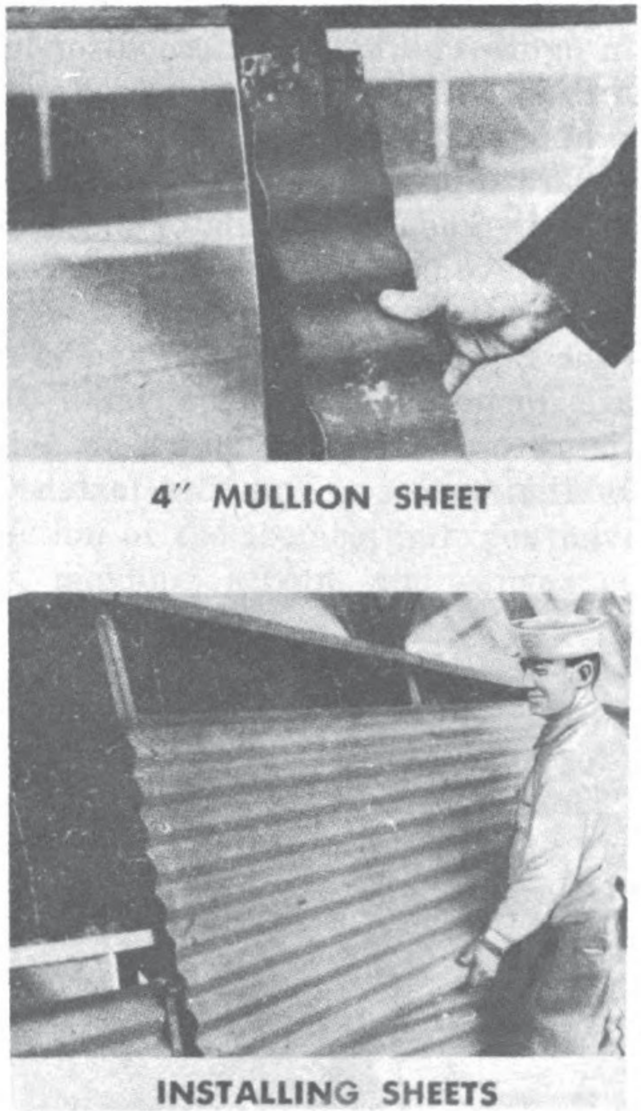


Figure 14–21.—Butter lap, butterfly button, and hinge.

Courtesy of Great Lakes Steel Corporation.

canopy rafters with double headed nails with steel and fibre washers 8″ O.C. You should always nail through the high point of corrugation. The top sheets at raised roof are curved and are made fast to the purlins. Refer to the layout of the corrugated sheets shown in figure 14–20.



Courtesy of Great Lakes Steel Corporation.

Figure 14–22.—Installation of corrugated sheets.

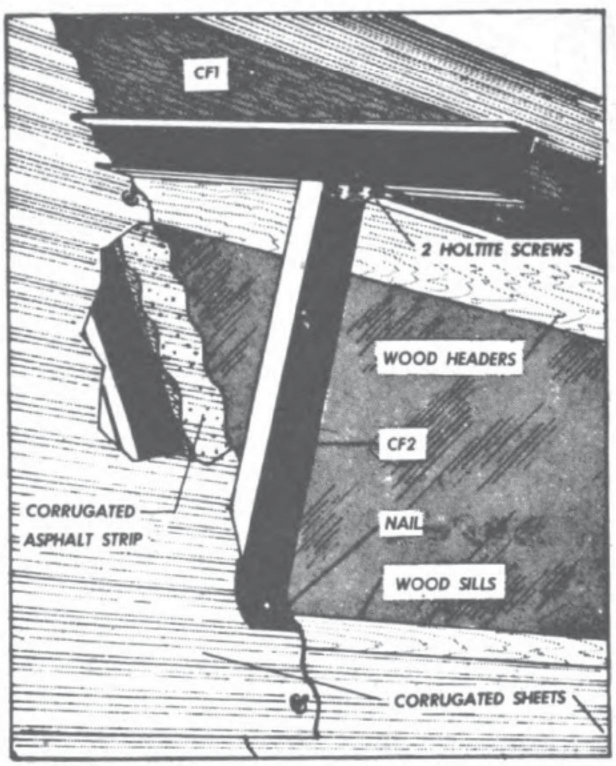
The installation of the exterior covering consists of the following five operations:

1. Start with row of sheets running under the canopied opening. Note that these sheets slip into a slot on

the under side of the wood sills. You should lap sheets 6″ at joints, and butter them with mastic. Omit nails at the bottom until hinged sheets are in place (see figure 14–21).

2. Install the eight 4″ corrugated mullion sheets (four at each side of hut) with hinges and butterfly buttons as shown in figure 14–21. The method for installing 4″ mullion sheets is shown in figure 14–22. You then cut the slot for the hinge. The 27½″ x 95½″ corrugated ventilator sheets are slipped under the lower edge of the row already installed. Then the ventilator sheets are fastened to hinges with stove bolts as shown in figures 14–21 and 14–22.

3. Then the 27½″ x 56″ sheets at jambs of canopied openings are installed. Slide the jamb sheet under canopy framing member CF 2 which should have been left loose for this purpose. You then fasten CF 2 to the



Courtesy of Great Lakes Steel Corporation.

Figure 14–23.—Canopy jamb.

rib with screws through corrugated sheet and corrugated asphalt filler strip as shown in figure 14–23.

4. The installation of the remainder of the sheets on side walls and canopy rafters is the next operation. Sheets should lap 6″ at vertical joints and 3½″ at horizontal joints. All laps should be buttered with mastic.

5. The fifth operation consists of installing bronze screening and flashings at the raised roof. Then the twenty-nine curved roofing sheets, each 27½″ x 144″, are installed. These sheets should lap each other 3½″. Secure these sheets to the purlins with double headed nails and steel and fibre washers 8″ O.C. Remember to always nail through the high part of the corrugation.

INSTALLING BULKHEADS

The tropical bulkhead is constructed from materials that are cut to size and ready to assemble. Now, to complete the erection of the tropical hut, you have only the door, panels, molding, screen, and canvas curtains to install. A plywood, or northern, bulkhead is furnished in five sections. These sections consist of 2 end panels, 2 window panels and a door panel. These panels are connected to each other by bolts. They are secured to the floor and end rib by means of clips. Raised ceilings—used to form continuous ventilators—and the sidewall ventilation is omitted in the erection of the northern hut. For the northern hut requiring stoves, two smoke stacks and a ventilator are furnished. These are shipped, knocked down, with curved flashing sheets for attaching them in place.

THE 40′ x 100′ QUONSET HUT

The 40′ x 100′ is erected in the same way as the 20′ x 48′ with a few exceptions. You erect this type of prefabricated structure on continuous concrete foundations. Concrete is placed in the forms provided. Wood blocks should be cut from the crating lumber and placed in the wet

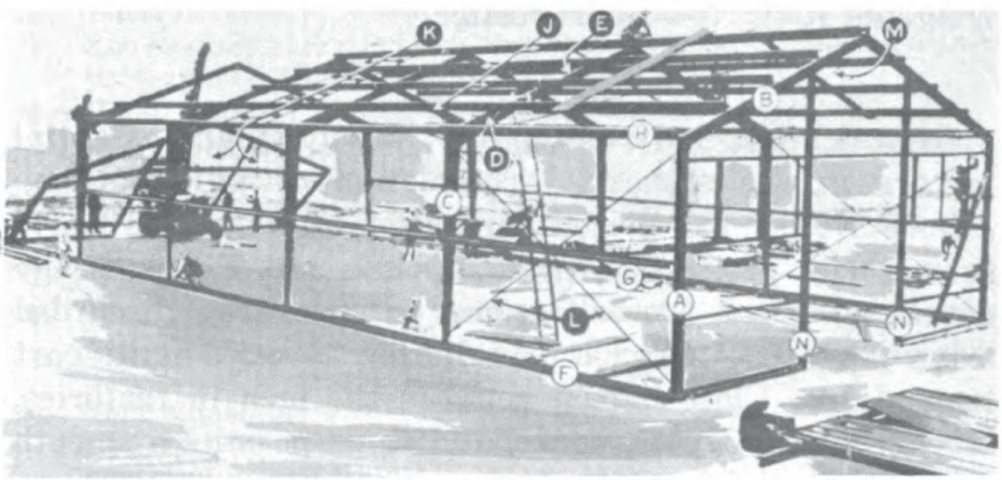
concrete. The ½″ round 8″ long anchor bolts are then placed accurately by using the 6″ channel plates as templates. After the concrete has hardened the wooden blocks are removed, thereby forming weep holes. You then lay the 6″ channel plates in position along the sides of the building. Channel plates are punched at the factory to fit over the bolts. When the channels have been correctly laid, a continuous line of channels extends down each side of the building, with approximately ⅛″ space between the separate channels. Carefully level the plates with small wedges at the bolts. Then, grout underneath them with cement mortar; slip washers over tops of anchor bolts and draw nuts down tightly. After you have laid the channel plates, the concrete floor slabs are poured. These slabs can be conveniently poured in three longitudinal strips. Two 14′ strips on each side of the hut and then the center 12 foot strip is poured. The ribs are assembled and raised to form the frame. You install the bridging, purlins, bulkheads and covering by the same methods outlined in the erection of the 20′ x 48′. Be sure to save all scraps, bands, nails, screws and crating material not used. You should sort and store this material for future use.

THE WESTWARD AND BUTLER BUILDING

The Westward Hut was developed for housing military personnel and for service building use. There are two basic types; a so-called standard hut used in the arctic and temperate climates, and a tropical hut. Either type is shipped in five packages and is readily erected. Both types have a 20′ x 48′ floor area. However, the tropical type has a 4′ overhang on both ends similar to the 20′ x 48′ Quonset Hut. The structures consist of laminated wood arch ribs at 4′ centers, with an inside and outside lining of nonmetallic sheets. Insulation is placed between the sheets in both types. The floors and endwalls are of plywood. These huts will withstand very heavy wind and

other loads. They may be protected from splinters by building earthfills on both sides and ends, up to the window sills. The erection steps of the Westward hut are similar to those of the Quonset hut. You'll use nails at all the joints instead of screws, as used in the steel arch rib hut.

The Navy also uses a rigid frame utility warehouse building. This 40′ x 100′ steel prefabricated structure is made by the Butler Manufacturing Company—from which it derives its name. The building frame consists of two ends and four intermediate frames for a 100′ long building. The end rigid frames are assembled from four sections, and the intermediate rigid frames are assembled from six sections. Connections between the



Courtesy of Butler Manufacturing Co.

Figure 14–24.—Structural members of the Butler Building.

haunch and the column of the intermediate rigid frame are welded at the building site. The end rigid frame is assembled and used as a welding jig. These frames are spaced on 20′ centers. They are bolted to base plate shoes at the bottom. You connect these frames by two wall girts, two eave struts, and eight roof purlins.

The end bays of the Butler Building receive a series of diagonal rod bracing in each side wall and in the plane of the roof. These rods are installed after the first end

frame and the first intermediate rigid frame are in place. You use these rods to square and plumb the building. When cranes are not available, gin poles may be utilized for the erection of the first end truss. After this truss is erected, you can erect the remaining trusses by attaching pulleys to the last raised truss. By using the two erection pulleys, you can pull the truss into a vertical position. The structural members of the Butler Building are clearly shown in figure 14–24.

A is the End Column, B—End Roof Beam, C—Rigid Frame Column, D—Rigid Frame Haunch, E—Rigid Frame Roof Beam, F—Bottom Angle, G—Wall Girt, H—Eave Strut, J—Purlins (four on each side), K—Sag Rods (double row), L—Wall Diagonal Rods, M—Roof Diagonal Rods, N—Door Posts.

TEAM WORK

Organization and combination of effort are essential factors in the successful completion of any mission. "TEAM WORK" has placed our nation ahead of the world in material progress. Knute Rockne and Frank Leahy developed great football teams because they discarded every play in which each man did not have a definite part to perform. Close liaison between the men in factories, storage areas, depots, docks, and ships permits a smooth flow of material to you and your shipmates.

The assembly and erection of prefabricated structures are simple and fast, provided there is teamwork. Your shipmates will be divided into crews for (1) setting the channels, (2) raising the ribs, (3) framing the bulkheads, and (4) applying the covering. Much time can be saved by you and your shipmates performing your respective portions of the work at the same time. The rib crew can be assembling ribs, and the bulkhead crew can be assembling the bulkhead framing, while the channels are being laid. Then, after the first four ribs from the end have been raised, plumbed, and braced, the bulkhead can be pulled up into position, while the erection staging

is still near the end of the building. The men applying the corrugated iron covering can begin their work after the first bulkhead is raised. Their work should follow closely behind that of the crew raising the remainder of the ribs. Meanwhile, the bulkhead crew should assemble the other bulkhead framing. They can have it ready for erection when the last rib is in position.

The development of "team-work" to its highest efficiency is necessary to quickly and smoothly complete the installations.

QUIZ

1. Of what does the floor joist assembly of the 20′ x 48′ Quonset consist?
2. What is the first operation in erecting the Quonset Hut?
3. Your second operation is laying the sills on the tamped ground. How are the sills laid?
4. What material is used for the flooring of the 20 x 48?
5. A plywood, or northern, bulkhead is furnished in five sections. What are these five sections?
6. What do you use as templates to accurately place the ½″ round by 8″ long anchor bolts?
7. When are the concrete floor slabs poured?
8. How are these concrete slabs conveniently poured?
9. Screws are used at all the joints of a steel arch rib hut. What do you use at all the joints of the Westward hut?
10. Your shipmates will be divided into four crews in the assembly and erection of prefabricated structures. What is the building operation of each crew?

CHAPTER 15

FIELD STRUCTURES

ADVANCED BASE CONSTRUCTION

You've read about how the Seabees carved scores of airfields from the coral of the Pacific Islands. The stories tell you, too, about how they blasted the rock and dredged the mud to build the many naval bases around the world. But how many stories have you read about the places in which the men lived while this great construction was under way? Some of those field structures wouldn't make story material perhaps, but a knowledge of them was and is essential for any combat construction outfit.

The Seabees pride themselves in their ability to hit the beach and throw up the essential field structures overnight. TENTS, FIELD TYPE LATRINES, INCINERATORS, and CAMOUFLAGE may not present your idea of all the convenience of home, but their construction is something that you do have to know.

CANVAS STRUCTURES

Tents provided for an overseas battalion are used for

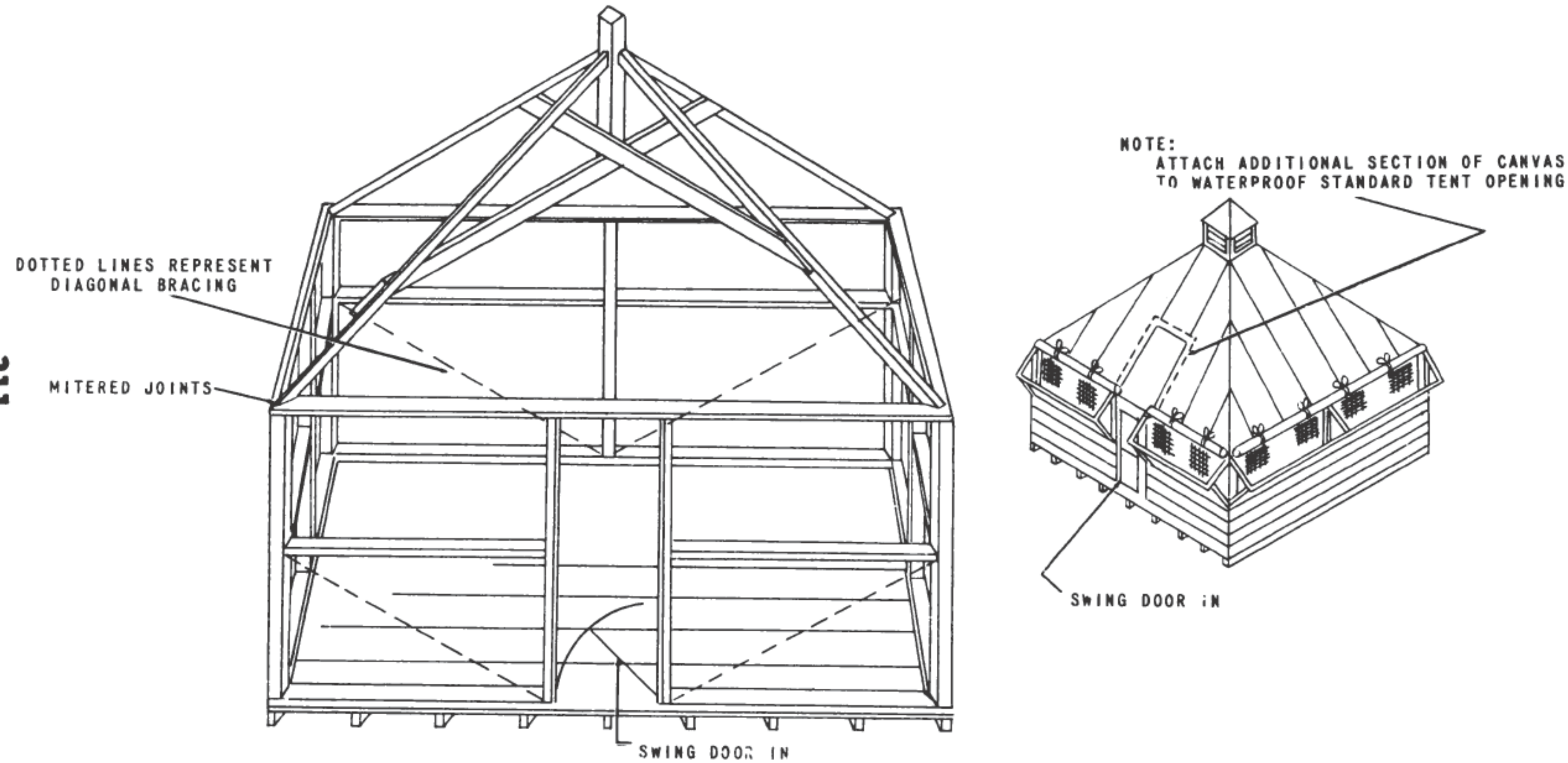


Figure 15-1.—Typical tent frame.

many purposes such as housing, messing, and storage. Each battalion is furnished with 16′ x 16′, 17′ x 20′, and 16′ x 50′ canvas structures. The 16′ x 16′ pyramidal tent provides comfortable sleeping quarters for five men and can house more in a pinch. The 17′ x 20′ storage tent may be used for temporary housing or for office space. Like the 16′ x 16′, the storage tent comes complete with pins, poles, and fly. The 16′ x 50′ hospital ward tent may also be used for temporary housing or storage. This tent has no fly, but it comes complete with pins and poles.

All Seabee tents are olive drab or khaki, and are fire, water, and weather resistant. Each tent comes folded, tied, and packed in a tent bag.

With a little improvising of the material at hand, you can make very comfortable living quarters from any pyramidal tent (see figure 15–1). To construct a tent frame, bolt or spike 4″ x 4″ sills to foundation supports, such as posts. In a hurricane or typhoon area, you should bolt the sills to foundation posts three and one-half feet in the ground. For your floor joists, use 2 x 4's fastened on edge to the sills. Then install a deck of plywood or planking. Framing for the side wall partitions can also be made from 2 x 4's. This skeleton framing is then spiked or bolted to the sills. For the 4-foot, exterior side walls, use any available material, such as sheathing, screen, or canvas. For rafters, you can use 2 x 4's. Rafters are attached to the center of a pole which is a 4-foot 4″ x 4″.

If you want a screened tent, install a screened door in the door opening on one side of the skeleton framing and screen the skeleton framing. To protect the occupants and their gear from rain, canvas flaps are rigged to the plates and screen door. These flaps are designed to be rolled up and secured during good weather, and battened down in foul weather. In typhoon and hurricane areas, these structures are secured to the foundation posts and manila line is rigged from the center pole to the foundation posts.

All tropical, light structures should be set on foundation posts at least one and one-half feet from the ground. This precaution will keep the interior of your living quarters from flooding during heavy rainfalls. Then too, in a hurricane or typhoon area you'll have to set up your tents so that they can be quickly collapsed when the wind becomes strong. Tents on a rigid frame will carry away, but those which have been collapsed and held down with sandbags or heavy rocks will ride out the gale.

FIELD TYPE LATRINES

The latrine box and accessories, including tent, urinals, tar paper, screen wire, and screen doors are furnished complete for installation. In figure 15–2, you'll notice

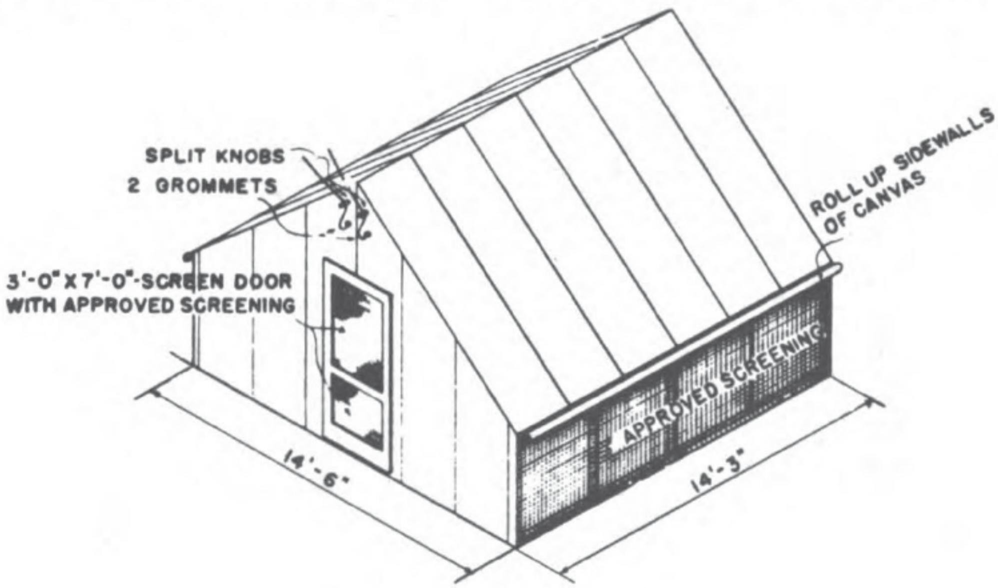
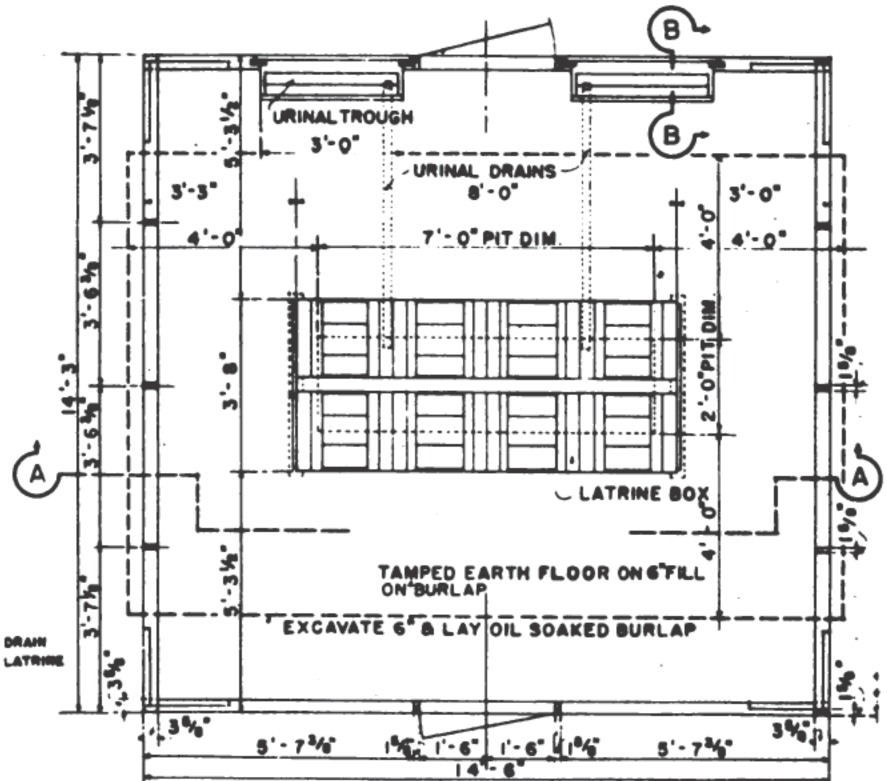


Figure 15–2.—Latrine pit tent.

that the standard latrine pit tent assembly includes roll-up sidewalls of canvas. It is an eight holer with the top measuring 3′ 8″ x 8′. The holes are large and rectangular. These holes permit flies to enter while the seat is in use, and the seat is very uncomfortable. So, if plywood is handy, you'll be able to make a better top. The standard 4 x 8 plywood is just right for an eight hole size, four holes on each side. Three-quarter inch, waterproof-

bonded plywood is a very satisfactory material for the top. 1 x 4's should be installed under the material for reinforcement. Oval holes should be cut on a bevel and sanded. The pieces cut out can be nailed on the underside of the lid to make a tighter closure. Don't forget to rig the lid to close automatically. Place the sill flush with the inside of the box or entirely on the outside. Line the box with tar paper from the top to the bottom. Then you'll have to dig the pit wide enough to prevent forming a ledge upon which feces, urine, or paper might fall. Therefore, for the standard box, dig the pit just over 4′ wide and just under 8′ long. Stringers are used across the pit to support the box. They must be placed so that they do not come under a hole.

In coral sand, the pit will have to be shored up to keep



PLAN

APPLICATION: This tent is equipped with an eight hole latrine box and two urinals.

Figure 15–3.—Latrine pit tent plan.

sand from sliding into the hole. All boxes need a metal or tar paper urine deflector. This deflector is converted into a trough under the front of the seat so that it will drain toward one end. From this end, install a pipe that will carry all urine to an outside soakage pit. You should build latrines in such a manner that they are fly-tight. The plan for a structure of this type is clearly illustrated in figure 15–3.

The URINE SOAKAGE PIT, when dug 4 feet wide, 4 feet long, and 4 feet deep, is adequate for 100 men. In a pit of this size, four pipes (see figure 15–4) should be installed. A hole, 2 feet wide, 2 feet long, and 4 feet deep is big enough for the use of 25 men, and needs but one pipe. Fill the pit to within one foot from the top with coarse rocks. Then place oiled burlap over the rocks, and cover to grade with sand or earth. In areas where rocks are not too plentiful, you can use tin cans or bottles for the first two feet of fill. Take a look at figure 15–4 to see the difference between a post or wall support trough and a metal, cone-style urinal.

Quite often you'll be assigned to construct SINGLE-SEAT

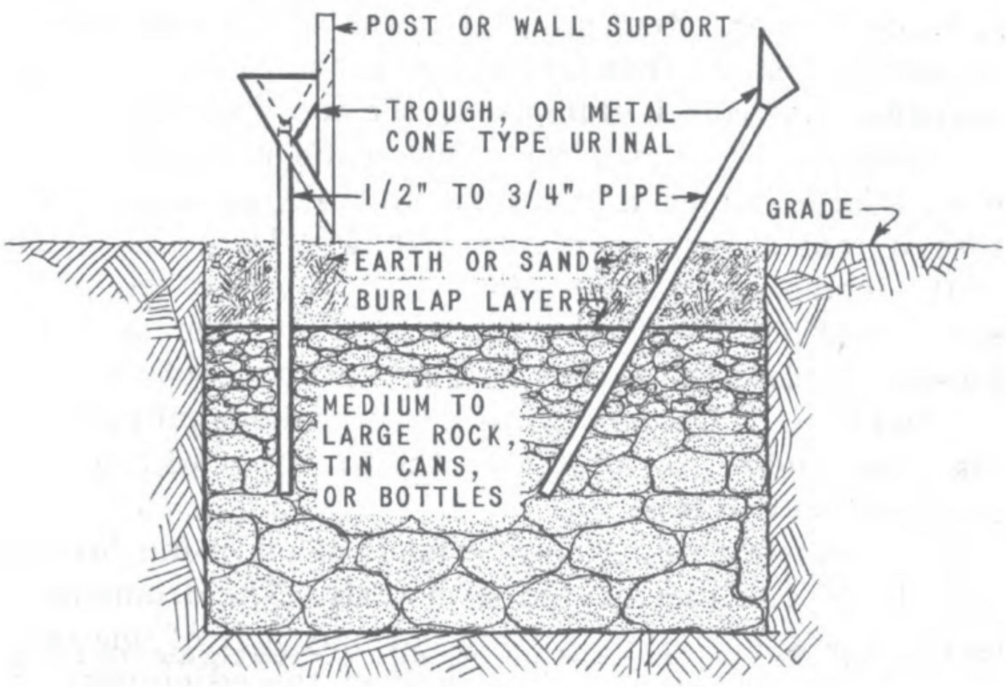


Figure 15–4.—Urine soakage pit.

latrine models, also. Where deep soil and low ground water permit, you can make a useful and sanitary model by boring a hole 10 to 20 feet deep with a post auger. A very simple cover will do. On sandy ground, you'll find the easiest way to keep sand from sliding into the pit is to make single-seat holes. These holes should be lined with two oil drums, with all ends removed. The drums should be set so that the top drum extends about 18 inches above the level of the ground. Then place a fly-tight seat and cover on it. A one-hole section of waterproof-bonded plywood can be cut to fit on a ledge at the top of the upper drum.

INCINERATORS

In advanced areas, incinerators are used to dispose of garbage. There are various types of incinerators. However, the HILLSIDE incinerator is the most efficient and the easiest to build. This incinerator requires a slope which will permit a trough or chute 12 to 18 feet in length. This chute should slope at about 30 degrees if it is lined with metal, or about 45 degrees if it is lined with rock. At the top, you should level off somewhat to allow for a suitable hopper. Remember that the upper end has to be near a road so that trucks can get to it to dump the garbage. Garbage is dumped at the top, and because it is slowly pushed down the slope while exposed to the heat, a large hopper is required. In rainy climates, some sort of roof to keep rain from running down the inside of the incinerator is necessary. The firebox at the lower end should also be covered for protection from the rain. Be sure to place the firebox so that the dried out garbage will fall into the fire itself. For a rock soakage pit beneath the lower end of the chute and the firebox, two types of construction will work:

1. A complete lining may be made of oil drums laid in a ditch like tile and covered with earth. The drums may be made self-locking by cutting out only half of one end. Then, bend the corresponding half of the adjoining end

and fold over this half-end. The baffles made by this method of joining must be placed uppermost in the chute.

2. More drying surface can be had if you line the ditch with rock. A cross section 3 feet wide should be about 2 feet deep. Cover this rock lining with flattened oil drums or other sheet metal, supported by cross rails.

Both types should have a good seal of earth around the firebox and the tube or chute. If the prevailing winds are known, you should place the firebox opening and the direction of the incinerator so as to take advantage of them. A rock-lined type of hillside incinerator, which can use flattened oil drums or metal sheets from Quonset huts for cover, is shown in figure 15–5. Usually, this

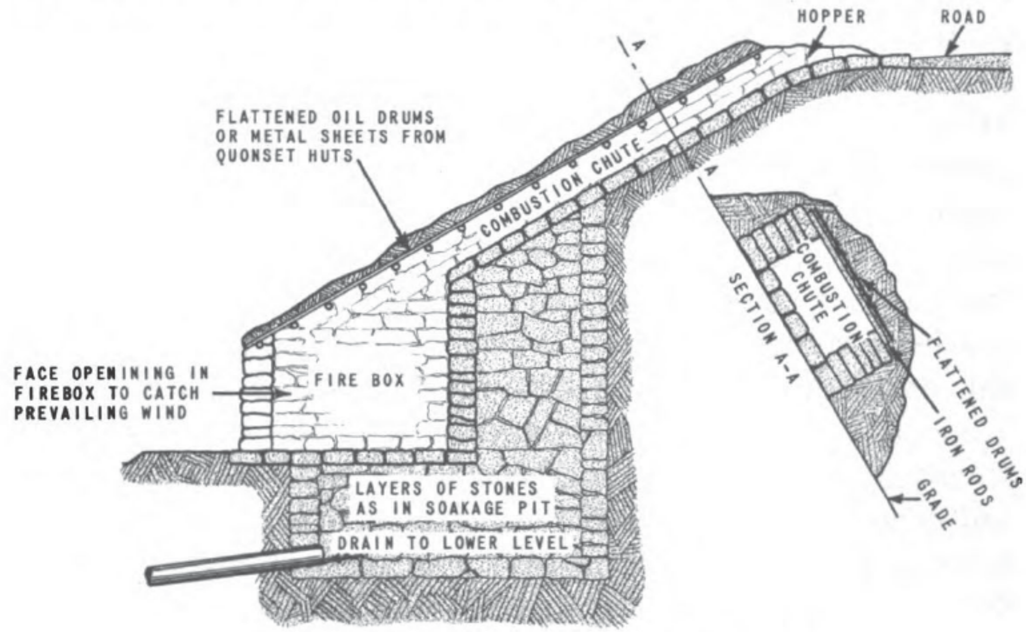


Figure 15–5.—Rock-lined type of hillside incinerator.

model is built with the lower 6 feet of the incline as a soakage pit. The bottom of the firebox also, is built as a soakage pit. Always use a rock similar to volcanic rock for the lining.

CAMOUFLAGE STRUCTURES

"Concealment" is the oldest and yet one of the newest weapons in warfare. Many definitions tend to give the

impression that CAMOUFLAGE is a highly technical and mysterious subject. Actually, it should be defined as the use of common sense. Aviation has made camouflage even more important. No part of construction operations is entirely safe from the aerial observer's eyes, cameras, and later his bombs.

From the air, objects are identified by applying certain basic principles to the object viewed. The identity is established on the principle of FORM, TEXTURE, SHADOW, and COLOR.

The Principle of Form

Nature has a definite pattern on the earth's surface, and wherever man goes this pattern is changed. Nature's pattern is irregular, while that of man is regular. In searching for manmade objects from the air, regularity of form or pattern quickly attracts the eye. AVOID REGULARITY OF FORM IN CAMOUFLAGE. Foot tracks and wheel tracks stand out when viewed from the air. They tell a very clear story to the enemy. You must not make more tracks than are essential.

Always follow natural landscape features, or disguise the destination of your tracks. Tracks or trails which stop suddenly are a sure give-away. Be sure to carry them far past their actual destination. Trucks, cranes, bulldozers, supplies, and temporary housing successfully screened from ground observation, may be highly visible from the air. Therefore, you must scatter objects as much as possible. You should use all available ground cover. Windshield reflections are a dead give-away on the positions of trucks and jeeps. A coat of dust or mud will dull reflecting surfaces.

The Principle of Texture

Texture measures roughness and determines the amount of light an object will reflect. This accounts for the various shades of gray in which an object appears on an aerial photograph. For example, a smooth surface

reflects the greatest amount of light. Thus, it is light in color. On the other hand, a very rough surface casts many shadows on itself. Therefore, it reflects the least amount of light, and gives the effect of darkness on an aerial photograph. In order that the appearance will be the same, camouflage must match the texture of the surrounding natural features (terrain).

One type of camouflage is made by sticking chicken feathers or leaves and foliage to chicken wire, cloth, or net, with a bituminous emulsion. It is then painted. This type of camouflage makes excellent flat tops to provide overhead cover for an object. Wood chips or bark stuck to a surface in the same manner also gives excellent texture. Spanish moss woven into nets makes a good blending together of trees in areas where moss prevails. Palm fronds can be woven into nets or used to replace burlap in building dummies. When you're using trees as a cover you can erect an excellent flat-top with two layers of chicken wire strung approximately one inch apart in the center and wired together around the ends. The two layers of chicken wire will keep the natural foliage upright. Spreaders may be used to hold the wire apart in the center. Place the strips of chicken wire 6 inches apart and insert branches between them. Foliage must be replaced or painted to match original color.

Fish nets can also be used to provide overhead cover for an object, either as a flat-top supported on a wire frame above the object, or as a drape placed over and around the object. In either case, a fish net must be tied in with some natural feature, such as a clump of trees or brush. Fish nets deteriorate more quickly than chicken wire, therefore, you should use them for temporary installations.

Besides the artificial materials of garnished fish nets and chicken wire, you can also use garlands for camouflage. Garlands are made by doubling a 40- by 2-inch burlap strip and knotting the double length in the center. These knots are secured to a light wire framework at

8-inch intervals in such a way that they will not slide on the wire. Garlands are useful for thickening natural or artificial overhead cover, and also for extending irregularities in the edges of nets.

The Principle of Shadow

The effect of a shadow is a most important consideration in camouflage. Every object casts a definite shadow. The shape of an object is often more easily discovered by the shadow it casts than by either its image or its tone. Camouflage must break up this shadow so that the identity of the object is blotted out. Use branches, garnished nets and good camouflage to break up shadows.

The standard material for garnishing is 7-ounce, 40-inch oznaburg, a cotton cloth something like heavy unbleached muslin. Burlap may also be used. Both fishnets and chicken wire are garnished by weaving strips of oznaburg, about 5 feet long and 2½ inches wide, into the net along irregular lines. The end of each strip should be allowed to dangle about 8 inches from the underside of the net.

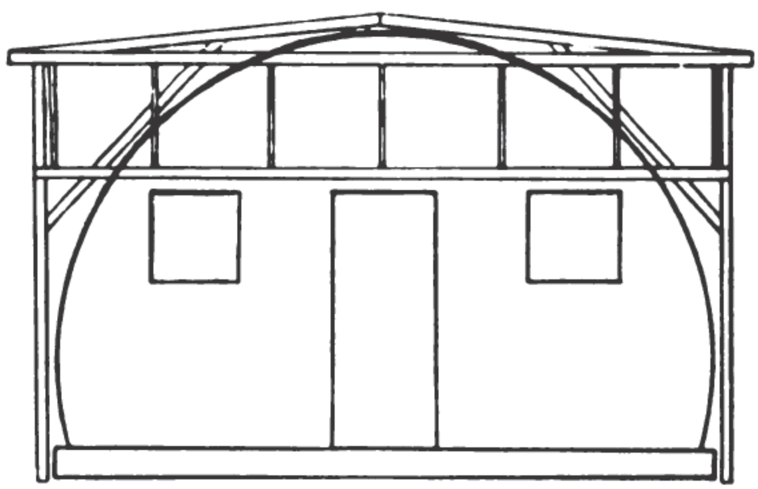


Figure 15–6.—End elevation—camouflage of Quonset hut.

In garnishing fish nets, the strips of oznaburg are woven close together in the center of the net so that about 70 percent of the mesh openings are covered. The garnishing must be thinned out gradually at the edges of

the net. Garnishing should be very irregular in outline. The thickly woven, central portion serves to conceal what may be under it. The thinned edges cast a faint, indeterminate shadow which, merging into the inequalities of the terrain, renders it unnoticeable in aerial photographs. Since the thinned edges allow objects under them to show, the cover must be much larger than the object over which it is placed. Each standard strip of chicken wire is garnished throughout, either thick for use in center portions of covers, or thin for use at edges.

You can camouflage Quonset huts by erecting a wooden framework as shown in figure 15–6.

To complete your camouflage job on a Quonset hut, nail laths to the vertical supports spaced 12 inches apart as indicated in figure 15–7A. Then cover the laths with oznaburg, paper, matting, or other available material as indicated by figure 15–7B.

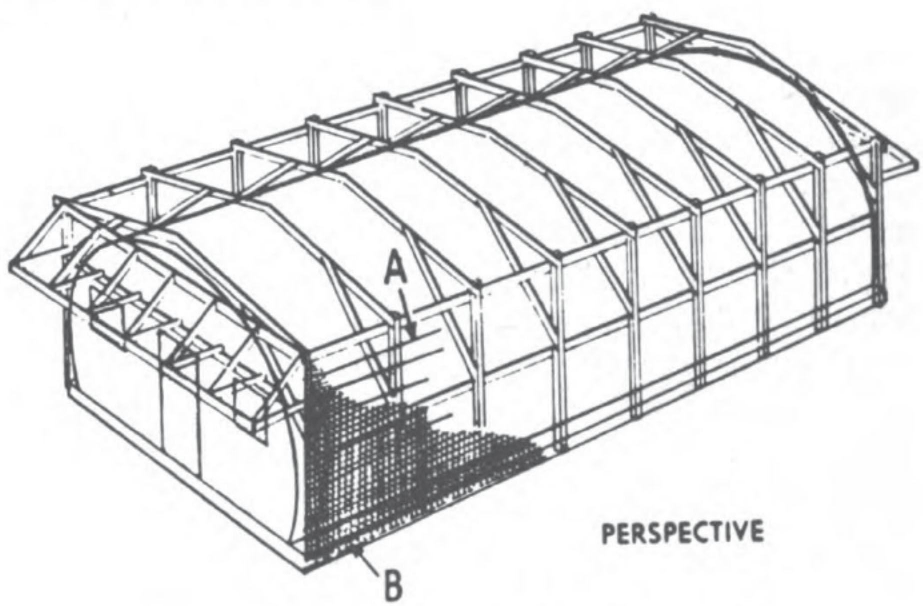


Figure 15–7.—Perspective-camouflage of Quonset hut.

The Principle of Color

The observer interprets the object as his eye sees it. Thus camouflage must blend in with the color of the surrounding terrain. The enemy generally uses infrared

or color film, which will disclose faulty colors in camouflage. Ordinary green paints appear dark on infrared prints, indicating that they are not natural. Evergreen trees, however, also appear dark on infrared film. Therefore, such simulated trees do not need infrared paint. Avoid off-colors in camouflage, and use only those paints and colors which have been proved.

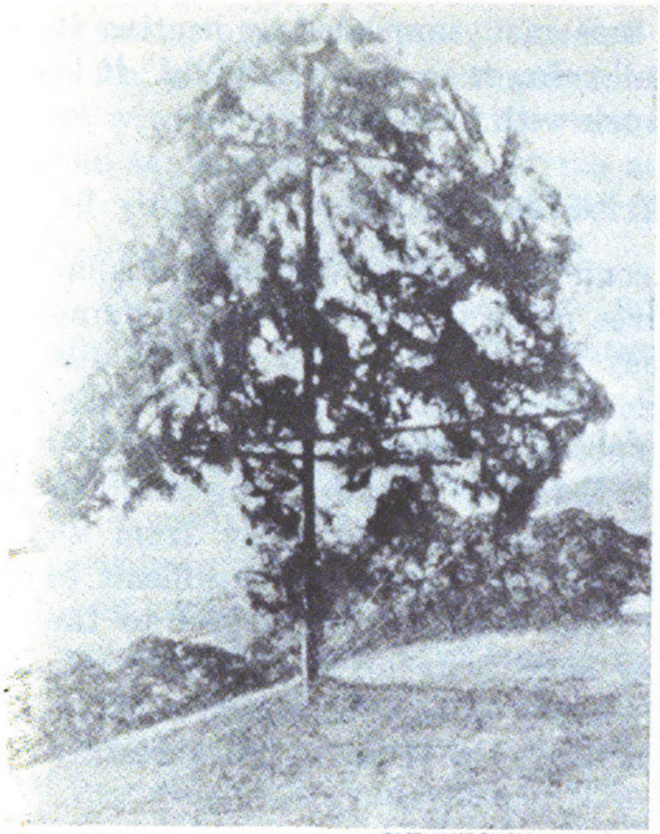
Garnishing for nets must be colored to fit the locality in which the net is used. In a stable situation, nets are furnished already garnished and colored to fit the particular sites. In mobile situations, garnishing or garnished nets are furnished in a neutral color and must be finally colored on the site.

Garnishing may be colored either with paint or dye. Paint is more satisfactory as most dyes fade rapidly. A casein-bound cold-water paint in paste form is the standard material. It is furnished in a variety of colors including burnt umber, burnt sienna, yellow ochre, green, golden yellow, ultramarine blue, black, white, and red. To match a particular piece of terrain, any two or more of these colors can be mixed to form the color needed. The proportions of basic colors to be used must be determined by trial and error for any given locality.

Paint can be applied by brush or a spray gun. The quickest method is by dipping in a vat. However, this method requires much more paint and thereby increases the weight of the finished product.

ERECTING WIRE FRAME

There are many needs for flat-top overhead covers of chicken wire or fish net. These covers must be supported by some kind of frame, ordinarily of wire. Posts for wire frames should be about 3 inches in diameter, cut square at the top, and sharpened at the bottom. Also, posts should be about 6 inches longer than the desired height of the net. Only soft steel or iron wire, about No. 12 or heavier, should be used for wire frames. If only



(a) STEEL WOOL AND WIRE ON PIPE FRAME.

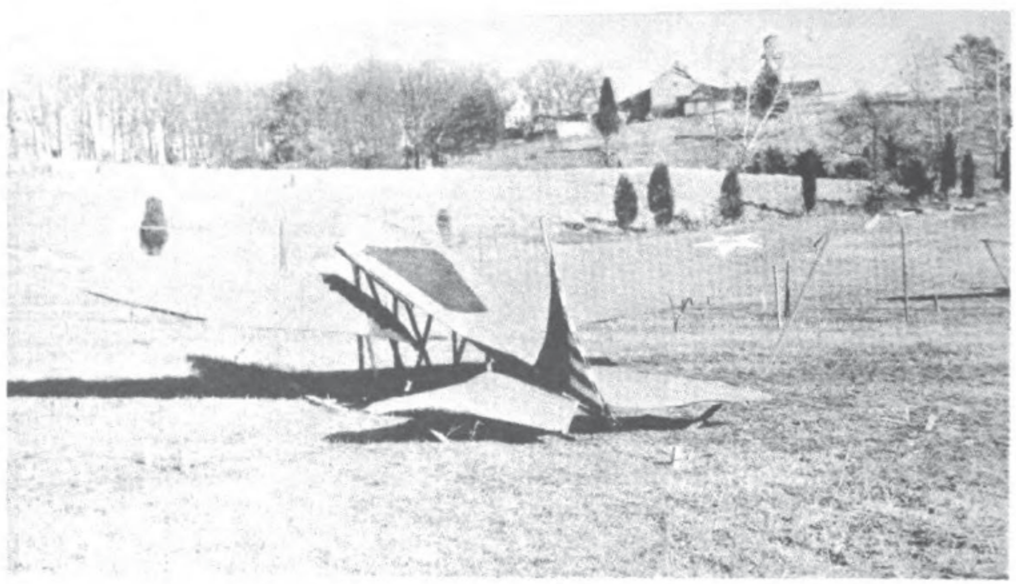
(b) CLOTH STRIPS AND CHICKEN WIRE ON WOOD FRAME.

Figure 15–8.—Dummy trees.

hard wire is available, it is easily annealed by heating it until red hot and then allowing it to cool gradually. It is impossible to do good work with hard wire.

DECOY INSTALLATIONS

Decoy installations, sometimes called dummy installations, are false structures made to look like the genuine building or article. They are constructed a suitable distance away from the genuine structure. Decoys are useful for one or more purposes. They divide enemy attack by offering more targets than are actually being occupied or used. Enemy attention is attracted away from an essential installation, particularly one that is difficult to conceal. Decoys deceive the enemy with respect to the volume of production or activity in an area. Then, too, decoys delay and confuse the enemy bombardier; thus causing him to waste his bombs by reducing the certainty of his aim.



Courtesy of Farrar and Rinehart, Inc.

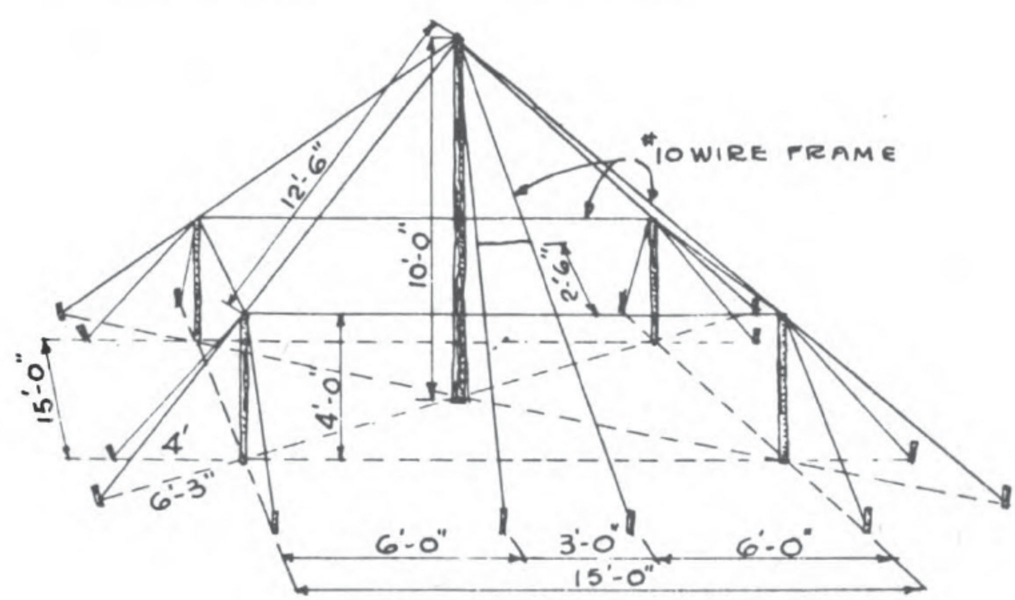
Figure 15-9.—Decoy plane.

Decoy construction should be the simplest possible so as to accomplish the intended purpose of deceiving the enemy. The construction usually consists of rough wood

framing or pipe frame. You can cover this frame with cloth, building paper, screening, or chicken feathers stuck to wire netting. Decoy trees and shrubs may be built in the same manner. Cloth strips and steel wool are quite effective in simulating the surface texture of natural foliage, as shown in figure 15–8.

To give effective deception, you must equip a decoy installation with all of the features normally associated with an installation of its kind. For example, an airfield is an incomplete decoy if there are no decoy planes disposed around the edges of the field. They should be made in a realistic manner and moved from time to time. A simply constructed decoy pursuit plane made of cloth and light wood, which is effective when observed from above two thousand feet, is shown in figure 15–9.

Decoy pyramidal tents, due to simplicity of construction, are very effective for field use. Actual tents are very difficult to camouflage. The wire frame layout for pyramidal decoy tents is illustrated in figure 15–10. Decoy tents should be placed in such a position that the maximum amount of light strikes them.



Courtesy of Farrar and Rinehart, Inc.

Figure 15–10.—Pyramidal decoy tent layout.

The doorway of decoy tents should always be left visible. Burlap is cut and secured to the wire frame as shown in figure 15–11.

Considerable success may be achieved by constructing decoy installations which are effective only at night. They consist merely of a system of lights which appear to be the important target which is actually located nearby. These lights may be turned on brightly when enemy raiders are known to be approaching, and then turned off except for the headlights of a jeep or two, and a few other dim glows which simulate violations of a blackout. Another method is to have the decoy lighting made up only of dim lights, so spaced that they appear to be the reduced illumination of the bomber's target.

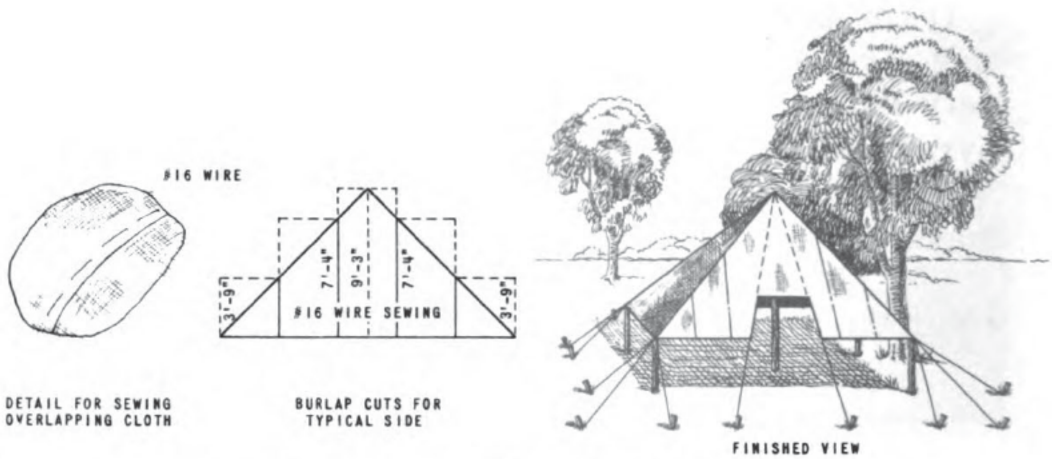


Figure 15–11.—Finished view of a decoy tent.

To complete the illusion created by large areas covered by camouflage nets, it is sometimes well to construct on the top of these nets, decoy structures, roads, and all of the other items which would normally be associated with such buildings. When a decoy is established, it is apparent that it must present a realistic appearance of activities normal to the genuine installation. For example, in a decoy truck parking area, the trucks should be moved about occasionally to give the appearance of mobility.

DETAILS OF CAMOUFLAGE

You must bear in mind that the object on the ground is first viewed from the air from a point miles away. From this distance, DETAILS of camouflage are of no importance. You can erect camouflage quickly, using locally available materials. Always build camouflage structures in accordance with the four basic principles: form, texture, shadow, and color. This type of camouflage is initially just as effective as laboriously erected camouflage which attempts to indicate each detail.

The bombardier's identification of his objective must be made in time to allow the release of the bomb load. If camouflage confuses him until his identification of the target is accomplished too late to allow him to release his load, then the camouflage has accomplished its mission.

QUIZ

1. Tents are provided for an overseas battalion for many purposes. Name three of the most important purposes.
2. In a hurricane or typhoon area you'll have to set up your tents so that they can be quickly collapsed when the wind becomes strong. Why?
3. How should you rig the lids of the latrine box?
4. How and with what should you line the latrine box?
5. Stringers are used across the pit to support the box. How should they be placed?
6. For what are incinerators used in advanced areas?
7. Why is the hillside incinerator used more than the other types?
8. Why should the upper end of the incinerator be near a road?
9. From the air, objects are identified by applying certain basic principles to the object viewed. The identity is established on what four principles?
10. Why should regularity of form be avoided in camouflage?
11. Tracks or trails which stop suddenly are a sure give-away. How do you correct this situation?
12. How do you prevent windshied reflections of trucks and jeeps?
13. Why must camouflage match the texture of the terrain?
14. Camouflage must break up the shadow so that the identity of the object is blotted out. How do you break up shadows?
15. What are decoy or dummy installations?
16. Should the doorway of decoy tents be always left visible?

CHAPTER 16

WATERFRONT STRUCTURES

"Shove that barge, tote that bale." You've got to get the supplies and equipment ashore in a hurry. There will be men to feed, roads to build, planes to fuel. Advanced bases aren't built on the principle of too little and too late.

How do you keep the supplies flowing from ship to shore? First, of course, you'll use pontoon barges and landing craft. But this method is slow and you're sure to have trouble with bad weather and crowded beaches. To do the job right, you need wharfs so deep-water ships can lie alongside and discharge directly into trucks.

And that's where you come in. As a Builder, you'll have to know how to set up and operate a pile driving rig. With it you'll drive timber and steel sheet pile, and you'll then build the waterfront structures needed to keep your base

rolling in high gear. And when the first ship ties up alongside the pier you've helped to build, you'll actually see that you've contributed something worthwhile.

WHARVES, DOCKS AND PIERS

A WHARF is a waterfront structure alongside which ships may lie to load or unload their passengers and cargoes. A QUAY, which you'll usually hear called a BULKHEAD in the Navy, is a wall with solid fill behind it parallel to the shoreline. A PIER is a wharf which projects out into the water from the shore line. DOCKS are actually the slips or waterways between two piers, although you may sometimes hear the word used incorrectly to describe a wharf, pier, or quay.

Both quays and piers are used extensively for advanced base waterfront structures. The method of building a quay generally consists of driving a steel sheet pile bulkhead. Then, earth fill is bulldozed or dumped between this bulkhead and the shore line, thus making a stretch of solid landing place. Frequently your battalion will have to dredge alongside the bulkhead in order to increase the depth of water for large ships. Dredging can be done before or after the installation of the bulkhead. If the dredged material is free of mud or clay, it may be deposited immediately back of the bulkhead. If not, it should be deposited well away from the bulkhead.

In the building of timber piers, timber piles are first driven to form bents and are then cut off at the required elevation. A pile bent is two or more piles driven in a row across the long dimension of the structure, and fastened together by capping and, sometimes, bracing. To these piles, caps are fastened. Joists are then secured to the caps, and the deck planking rests on the joists in the same manner as the floor of a building. The shore end of timber wharves and piers is made secure by the use of a steel sheet pile bulkhead or a riprapped earth fill.

TYPES OF PILES

You'll find PILES used in the construction of nearly all types of waterfront structures. These members are classified into the following six groups in accordance with their structural purpose: BEARING, BATTER, FENDER, DOLPHIN, MOORING, and SHEET PILES.

BEARING PILES support the load coming on a structure and should be straight from butt to point. The length of piles depends upon the depth of the water and the condition of the bottom. Piles should be driven straight and braced. Timber piles for a pier are generally driven in bents which are 10 to 12 feet apart. The piles in these bents are usually 5 to 10 feet on centers. When heavier loads are to be supported, the piles must be driven closer together. The exact distance is calculated by the designer. **To prevent decay and destruction by marine animals, bracing and piling are frequently creosoted.**

BATTER PILES are bearing piles driven at an angle and provide bracing for pile supported structures. One or more batter piles is driven in each bent and framed to it.

FENDER PILES protect the pier or wharf by absorbing the shock when ships strike them. They are driven about 2 feet out from the curb of a pier or wharf, and are spaced at 6 to 10-foot centers. It isn't necessary to drive them as deep as the bearing piles. The fender piles are connected to the pier or wharf by long bolts and timber blocking pieces called chocks.

A DOLPHIN is a cluster of piles held together by bolts and a wrapping of cable. It is used for mooring a ship and for protecting a wharf. Inner piles are driven vertical, and the outer piles are driven on a batter as shown in figure 16–1. The same figure indicates how the batter piles are secured to the vertical piles with cable.

MOORING PILES are used to secure the lines from a vessel. They are driven between pile bents and approximately 3 feet in from the curb of a pier or wharf. They must be securely braced to the adjacent pile bents and

should rise about 4 feet above the deck of the pier or wharf. They should be spaced approximately 30 feet center-to-center. If bollards or cleats are available, you do not have to install mooring piles.

SHEET PILES are interlocking piles which can be driven into the ground to form a continuous wall or bulkhead. They may be of steel or wood.

Pile locations are determined from working drawings and with the assistance of a surveyor. When driving ashore, a stake is driven to mark the location of each pile.

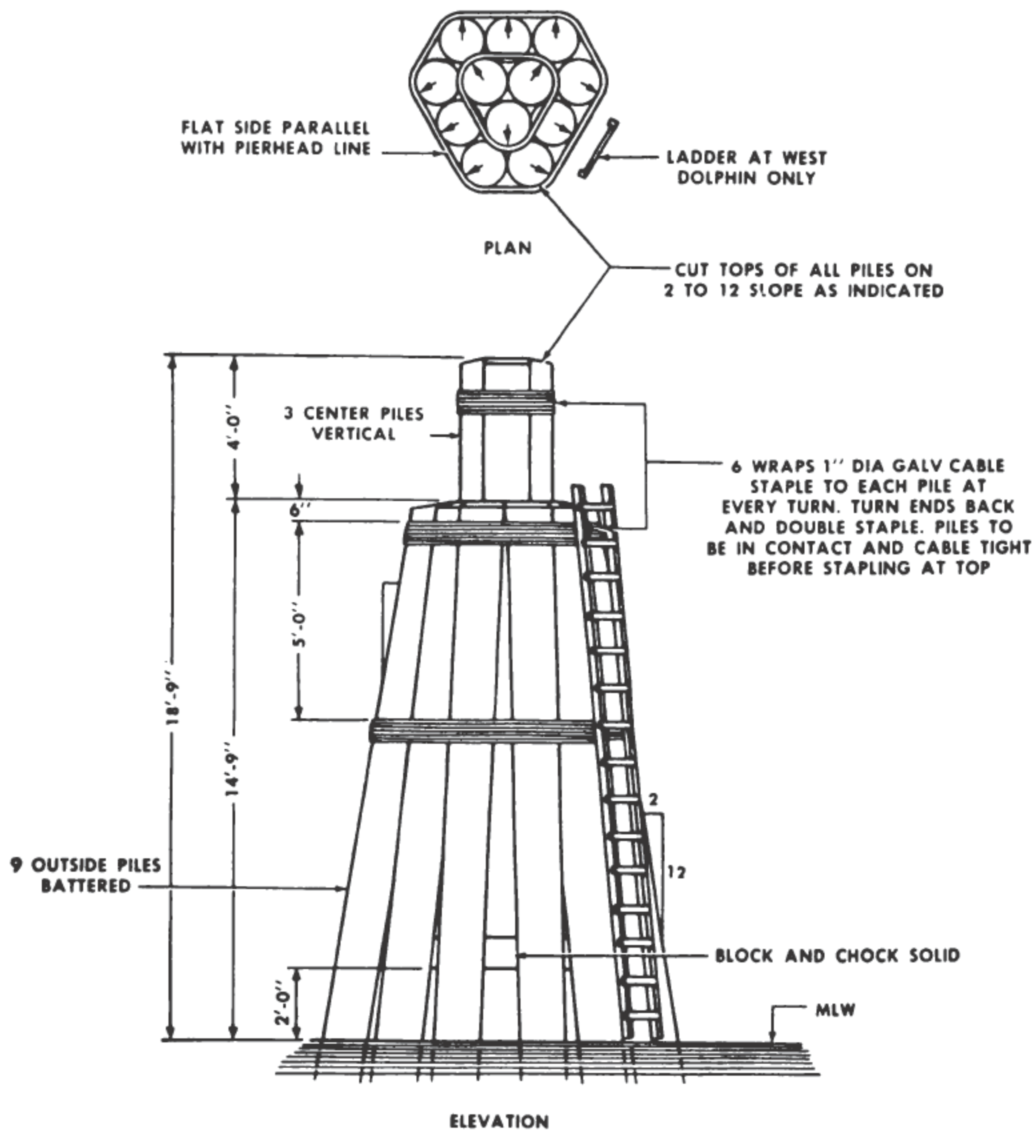


Figure 16–1.—A dolphin.

When the pile is to be driven, the stake is pulled, and the end of the pile is placed in this hole. The driving leads are sighted for plumb in both directions, the hammer is lowered, and the pile is started on the way down. If the pile is to be driven in water, its location is determined by ranges or grids laid off by a surveyor.

PILE DRIVERS AND PILE-DRIVING METHODS

Referring to figure 16–2, you'll see that the pile-driving frame consists of a framework of timber or steel sup-

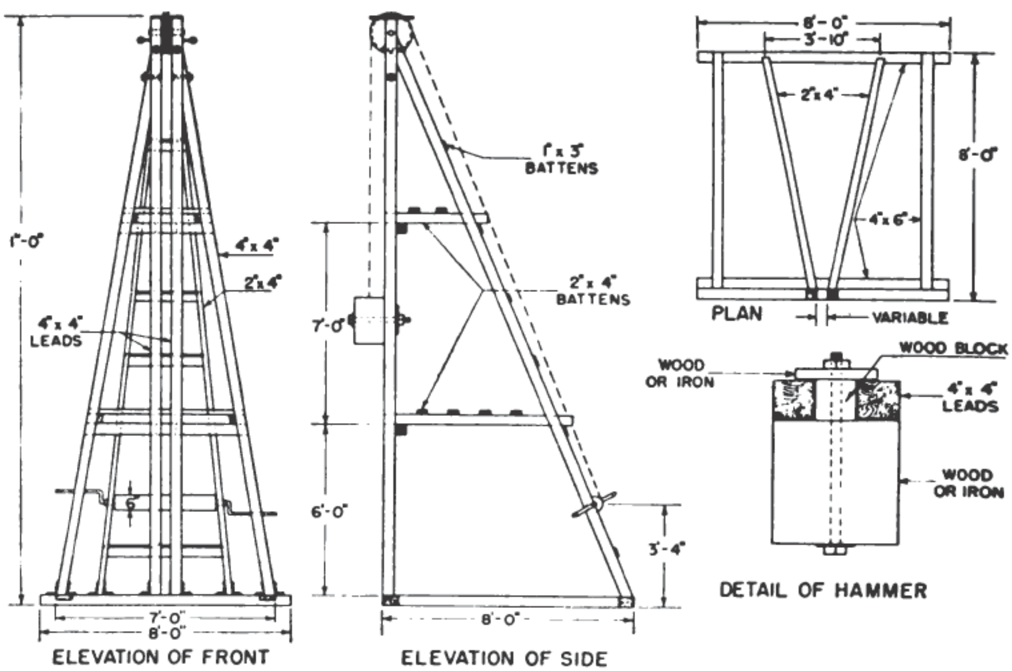


Figure 16–2.—Pile-driving frame.

porting two vertical pieces called leads. The hammer is guided by these leads. It has slots in which the hammer guides fit, or the hammer may be fitted with a bolt with a plate on the back which overlaps the leads to hold the hammer in place. A pulley is placed at the top of the leads and is used with a rope or cable to raise the hammer.

Hammers are made of steel. Drop hammers are raised by a power winch. The weight of the hammer should be 1½ to 2 times the weight of the pile. The Seabees have many times improvised pile-driving frames and

leads from various materials, such as pipe, railroad rails, channel beams, timber, logs, or a combination of these.

If your battalion is fortunate enough to be equipped with a steam or an air hammer, then of course you'll use that instead of a drop hammer. A steam or air hammer rests on the head of the pile all the time it is driving. Its driving power comes from parts within the hammer itself. The hammer strikes relatively light blows in such rapid succession that the pile is kept in continuous motion. Steam hammers drive piles more rapidly than drop hammers and injure the piles less. They can also be used for pulling sheet piles and sheathing.

Steam or air hammers are of the single-acting and the double-acting type. A single-acting power hammer consists of a heavy ram which is raised 2 to 4 feet by admitting steam or air under pressure to a cylinder located above the ram. The pressure acts against the underside of a piston which in turn is connected to the ram by a piston rod. The ram falls by gravity when the steam or air is cut off. You can place the hammer on the pile within the leads, or you can suspend the hammer from the boom of a derrick or from a gin pole.

The double-acting type not only lifts the ram by steam pressure, but also uses the steam to drive the ram down. This action increases the energy of the blow exerted by the hammer, and permits the use of a lighter hammer.

You'll frequently use floating pile drivers in waterfront building operations. A floating pile driver, with drop or steam hammer, is mounted on a pontoon or barge that may be towed. While on the job, it is held in position by anchors or by moorings to fixed objects.

The water jet is also frequently used to drive piles. A pipe is placed at the side of a pile and water is forced down it to wash the material away from the point of the pile. The pile drops into the space formed by the jet of water. Some of the water from the jet rises along the sides of the pile and acts as a lubricant to make the driving easier. You can place a load on the pile to assist

in forcing it down, or strike light blows with a pile hammer. In addition to the jet which delivers water to the point of the pile, jets may be used to deliver water along the side of the pile to assist in decreasing the frictional resistance. The final penetration is usually given with a pile hammer after the jet has been turned off. The water jet may be used in many types of earth, but it operates best in sand. Piles driven with a water jet aren't injured in driving, so this method is particularly suitable for precast concrete piles.

TERMS USED IN TIMBER PILE DRIVING

Wood fibers become crushed in the head of the pile as a result of the constant blows from the hammer. This is called BROOMING. Rings around the head prevent the pile from splitting, but the cushion formed by brooming reduces the driving effect of the hammer.

SPRINGING is a sidewise vibration of the head of the pile caused by blows of the hammer. Springing occurs if the pile is crooked, or if the head of the pile isn't square so that the hammer strikes on one side of it. Excessive springing also occurs when the pile and direction of the fall of the weight are out of line.

Under good conditions, a BOUNCE of the hammer will occur at every blow, but decided bouncing will occur in the following cases:

1. When penetration ceases.
2. If the hammer is too light.
3. If the fall is too great.
4. If the head of the pile is crushed.

OVERDRIVING is a frequent cause of injury to piles. The result is that the pile is broken, crushed, or split. Overdriving is indicated by excessive springing or bouncing of the hammer.

When it is necessary to drive a pile below the leads, a FOLLOWER or DOLLY is used. The simplest form is a length of pile ringed at both ends and resting on the pile head.

It is kept in place at the bottom by a dowel, and at the top by gage bolts between the leads of the pile-driving frame.

PILES, SHOES, RINGS, AND BOLSTERS FOR TIMBER PILES

A pile to be driven into soft ground must be cut off square. When the ground is hard or contains large boulders, the point of the pile must be covered with a metal shoe or strap iron to prevent the pile from splitting or becoming battered at the point. Since the shoe is not intended to increase the penetrating power, it should be blunt. Rings are used to prevent the head of the pile from splitting while being driven. The rings are fitted tightly over the end of the pile and fastened with nails. Several turns of wire may be used instead of iron rings. The head of the pile must be sawed off square, whether or not a ring is used. When the piles driven into soft ground are not long enough to reach firm footing, more bearing is secured by bolting bolsters to the sides of the piles. Brush or logs are sometimes placed under the bolsters to give extra bearing surface. Bolsters are used under exceptional circumstances only. Lagging of piles by spiking or bolting timbers to them on the sides also increases bearing resistance in soft ground.

DRIVING STEEL SHEET PILES

Either a drop hammer or steam hammer mounted on a suitable rig can be used for driving steel sheet piling. Refer to figure 16–3. You'll find, though, that the steam hammer is better since it puts a constant weight on the pile. The steam hammer delivers quick, short blows which keep the pile moving. You do not have to use a cap over the end of the pile while it is being driven. However, a cap is recommended to save the top of the pile from being battered and to insure a square blow. Piles which are to be pulled and re-used should always be protected in this way. You should select a driving cap shaped to fit the pile section being driven.

You can facilitate driving sheet piling under water or below the pile driver leads by using a follower. Care should be observed in driving to keep each pile plumb. If the first sheet pile driven is vertical, you'll have little difficulty in maintaining a straight wall. Piling that deflects badly or refuses to penetrate on account of serious buried obstructions should never be forced since it is likely to separate at the interlock and twist out of

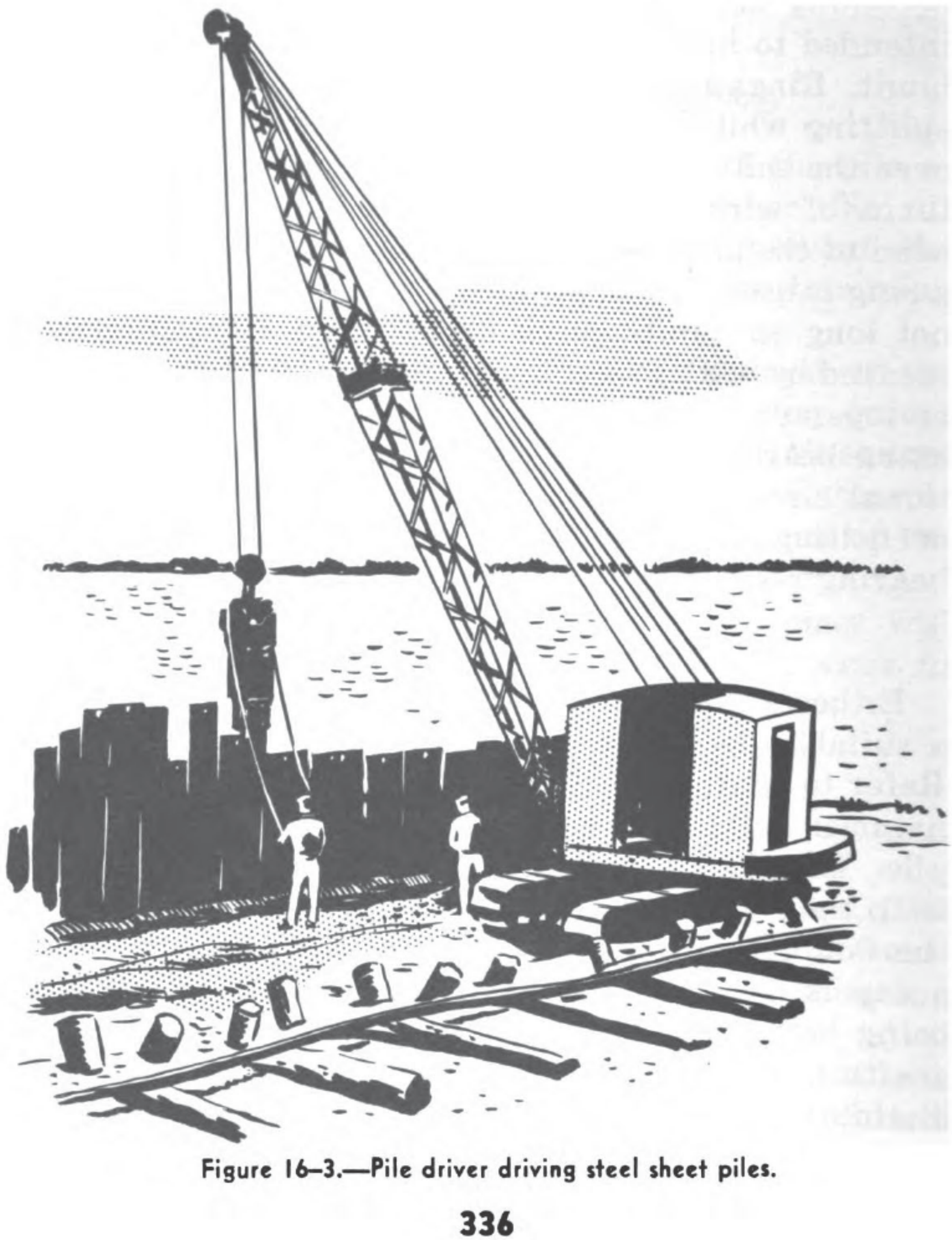


Figure 16-3.—Pile driver driving steel sheet piles.

shape. When the decreased movement of the piling under the hammer blows indicates serious obstruction, it is often advisable to continue the line, leaving the obstinate piles projecting above the rest until later. Then the obstruction may be removed and all parts of the piling wall properly set.

When driving the sheet piles for a cofferdam, you'll find that it is usually best to first place them all the way around. Then you can work them down gradually. This method is called GANG DRIVING. It should be used rather than to drive each one all the way down as it is placed. Driving piles one at a time is likely to result in getting the sheet piles out of plumb.

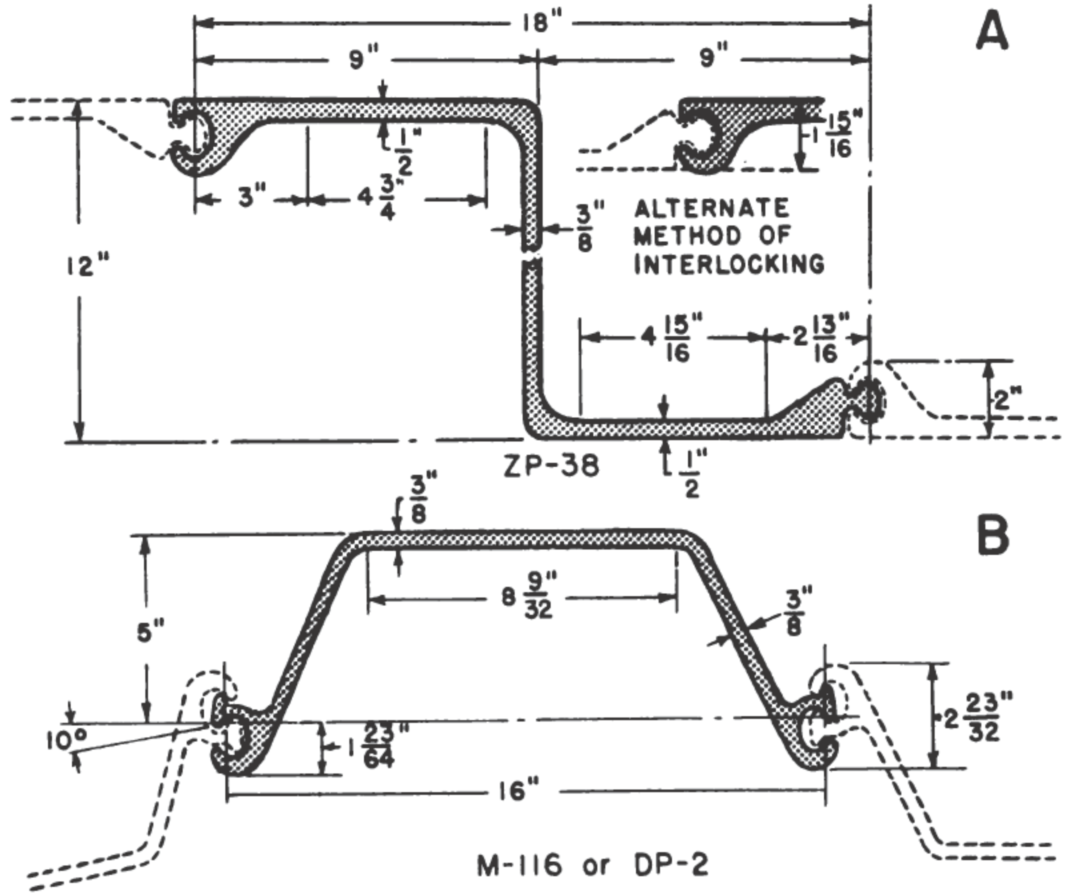
STANDARD PLANS, STANDARD METHODS

You can imagine the time that would be wasted if every advanced base waterfront structure was designed in the field. You would have to make construction drawings for every wharf built, and you would have to order many different sizes and shapes of piles and fittings to go into the special structures you designed. This would take up valuable shipping space and it would require a genius to keep the parts sorted out in the supply depot.

To get around this difficulty, the engineers have drawn up what are known as Standard Plans. Thus, you can take a look at your field conditions and select the plan which comes closest to fitting them. Also, each plan has a list of the material required to make a fixed length of wharf. If you want to build a structure three times as long as the one called for on the plan, you simply order three units.

All structures of a particular type are constructed in accordance with the same principles. For example, if you know how a sheet pile bulkhead is constructed in thirty feet of water, you will be able to understand how to build one in fifteen feet of water. The same holds true with a timber pier. You use the same methods regardless of the size.

To start a sheet pile bulkhead, timber piles are first driven along the proposed line of the wall. The location of these piles will be determined for you by a surveyor. You then secure a wale to these piles, thereby making a template or guide which will assist you in driving the steel sheet piles in a straight line. ZP-38 steel sheet piling is provided for the bulkhead. Taking a look at figure 16–4,



Courtesy of Bethlehem Steel Co.

Figure 16–4.—(a) ZP–38 steel sheet pile.
(b) M–116 or DP–2.

you'll notice that this Z-shaped pile has a different type of interlock than the M-116 or DP-2. If you drive this type of sheet piling with the ball or male end leading, no soil can become trapped in the interlock. Therefore, any tendency to force open the interlocks during driving, due to the packing of this soil, is eliminated. Ordinarily

sheet piles are driven in pairs. It is important that the first pair be driven truly vertical. Be sure to check it by every means available in order to determine if the pair is vertical. Otherwise, your completed bulkhead will be out of line.

You place the first pair in the leads. Then the hammer is lowered, resting on the piles. The weight of the hammer will sink the unit through the soft bottom. Then you should drive the pair with light blows until they are self supporting. Succeeding pairs are interlocked with each other and driven down the same amount as the first pair until at least 50 feet of bulkhead has been strung. The piles should then be driven down in increments of approximately 5 feet at a time until they are in final position. Bear in mind that in no case should two pairs have a differential of more than 5 feet.

For the standard bulkhead shown in figure 16–5, to obtain the number of pieces required, all you have to do is to multiply the length of the wall in feet by ⅔. The detail plan calls for nine lineal feet of bulkhead—$9' \times 2/3 = 6$ pieces. That is why you'll be provided with six ZP–38's for each nine lineal feet of bulkhead. By observing figure 16–5 carefully, you'll see that upper and lower wooden wales, 8″ x 12″, are then bolted to the front bulkhead as indicated.

A wale is also called a waler or ranger. It is a member extending along a row of piles and fastened to them. The wale serves to support the fender system. The fender absorbs shock, protects a structure from floating objects, and also is a protection to floating craft. Two wooden fenders, 10″ x 12″ x 10′, as shown, are made secure to the wales. Upper and lower chocks, 8″ x 10″, are placed and made fast between the fenders as illustrated.

BUILDING ANCHORAGE FOR BULKHEAD

The front wall bulkhead must be anchored back to the rear wall anchorage, called the deadman, so as to

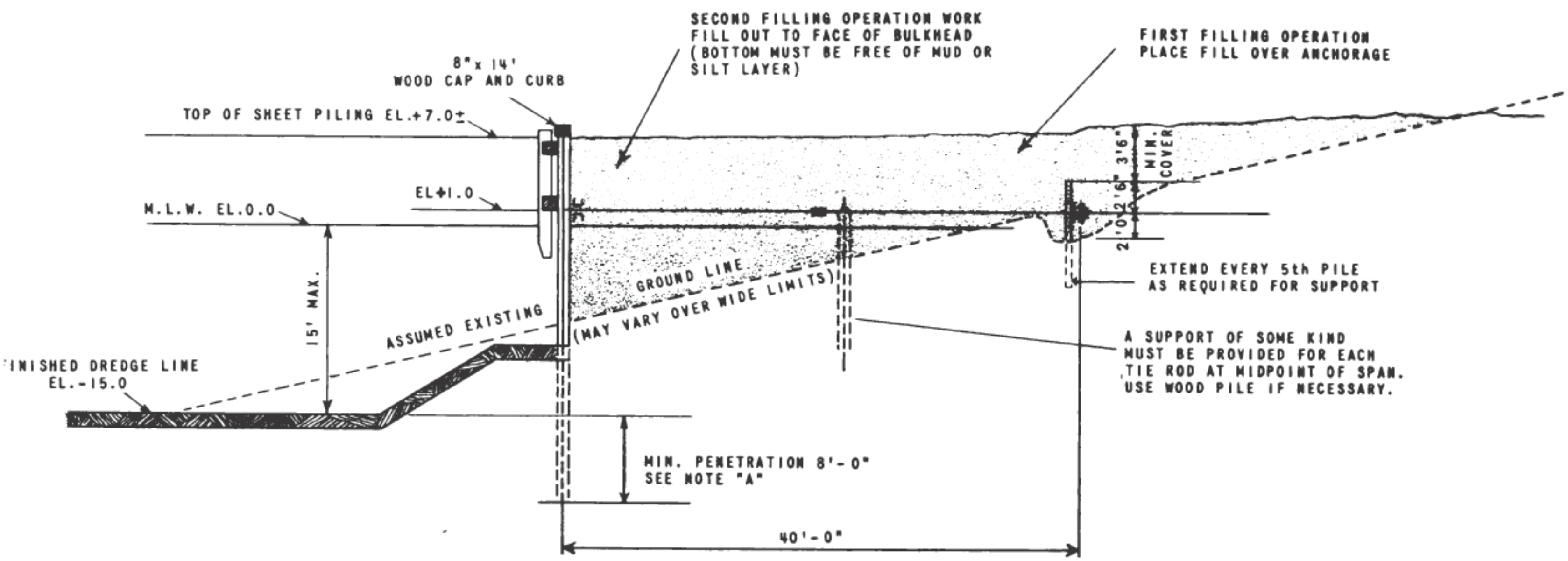
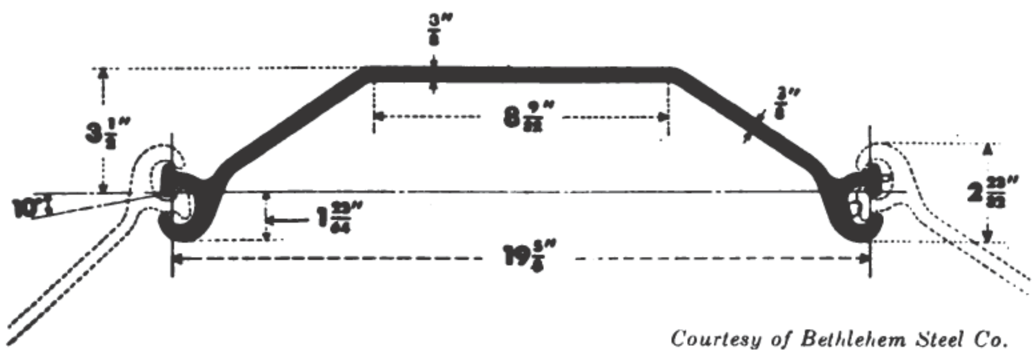


Figure 16–5.—Detail plan of bulkhead and fender system.

resist the pressure of the water as well as the pressure of the earth fill. Otherwise, these pressures would overthrow the bulkhead or cause it to slide. You build the deadman wall in exactly the same way as the front wall and parallel to it. However, lighter and shorter steel sheet piling is provided for the job. Five AP-3's or five M-115's are used to build the standard section of the rear steel sheet piling wall. By taking a good look at figure 16–6, you'll see the difference between the AP–3's, or M–115's, and the ZP–38's or M–116's.



Courtesy of Bethlehem Steel Co.

Figure 16–6.—AP–3 or M–115.

Two 12″ steel channels are bolted to the rear of both the front and rear bulkheads. These serve as an anchorage for the tierods which tie the two bulkheads together. The tierods are drawn up tight by means of turnbuckles. Notice that washers are used under all nuts and boltheads.

After the channel wales and tie rods are in place, the template is removed. So as to strengthen the installation

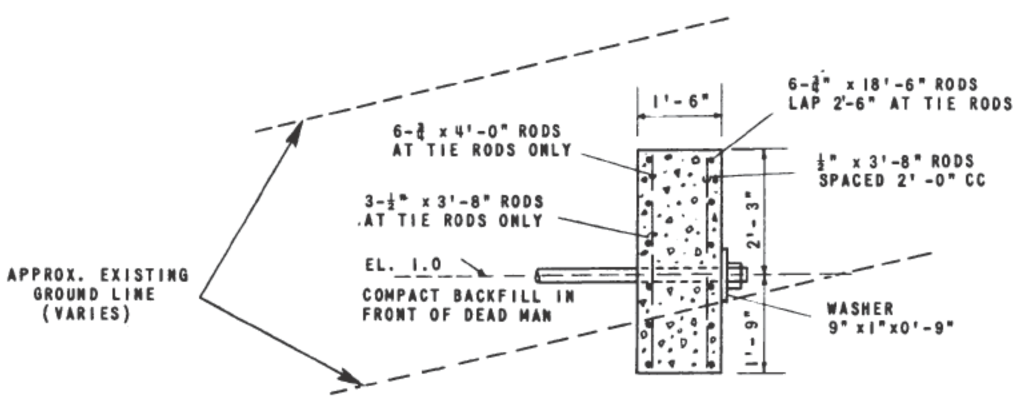


Figure 16–7.—Concrete deadman.

of the deadman, it is a good idea to bulldoze and pack earth fill and rocks firmly around the rear wall anchorage. Sometimes you may use a continuous concrete deadman in place of steel sheet pile anchorage where elevation of ground line makes its use advisable. Portland cement and round deformer steel bars are provided in the bill of material for this purpose. Figure 16–7 shows clearly how a concrete deadman is constructed.

RELIEVING PLATFORMS

The designed bulkhead already discussed, can be used only where very favorable soil conditions prevail. For a dredged depth of 30 feet, the bottom must be of gravel, sand, coral, or combinations of firm materials. Fill material should stand on a slope of not flatter than 1 on $1\frac{1}{2}$ when dumped in place. Then too, the fill material should be granular in character adjacent to the bulkhead

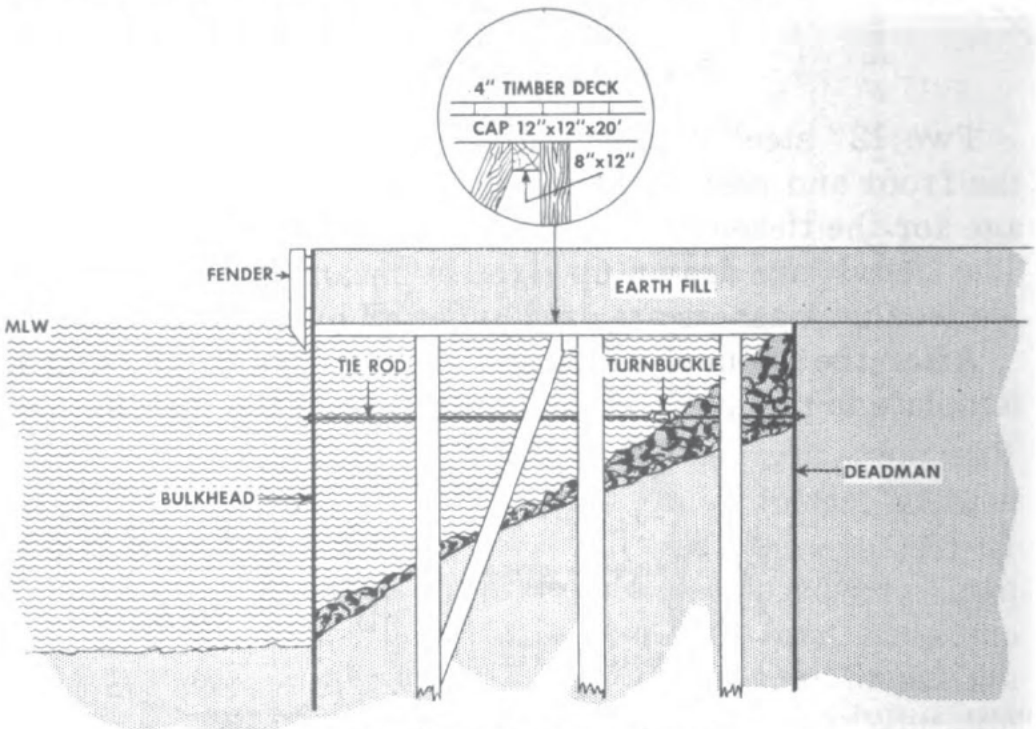


Figure 16–8.—Relieving platform.

so water pressure will not build up behind the wall. When soil conditions do not meet above specifications or where fill is to be placed by hydraulic method, then you'll

probably be told to use relieving platforms with batter piles. Relieving platforms are actually similar to timber piers which will shortly be discussed for you. Timber piles are driven between the steel sheet bulkhead and anchorage. A cap 12″ x 12″ x 20′ is bolted or spiked to the top of the piles as shown in figure 16–8. Then a 4-inch timber deck is made fast to the caps. Fill is placed on the timber deck to level the top of the front wall bulkhead with the surrounding terrain. By this method, you'll readily see that the pressure of the earth fill on the footing of the front wall is eliminated. Also note in figure 16–8 how an 8″ x 12″ has been fastened to the bottom of the cap. Then a batter pile, one driven on an incline, has been fastened to the 8″ x 12″.

TIMBER PIERS

The width of the pier is specified for you in the working drawings. The direction of the length of a pier, as a rule, is perpendicular to the bulkhead wall or shore line. Timber piers are of two general types:

1. Those having the floor system or deck supported on piles, and

2. Those having the floor system or deck supported upon timber cribs.

The top of the deck must be above high water, but low enough to permit the loading of vessels at low tide. Pile piers are usually built with piles in traverse rows 8 to 12 feet on centers, the piles in the rows being 3 to 10 feet on centers. The close spacing is used for heavy loads or where the pile resistance is small. When timber cribs are used they extend the width of the wharf and are usually spaced 15 to 35 feet on centers. A pier need not, as a rule, be braced longitudinally. Impact of vessels in this direction is taken care of by the bulkhead or the earth at the shore end.

The lines of traverse piles should be placed parallel to the current. They should be strongly sway-braced, the

braces being carried down at least as low as low tide. If the piles are to be driven into soft bottom, deep water, or in a rapid current, use batter piles to stiffen the wharf against the impact of vessels. Guard or fender piles are used to protect the structure from the beating it will take from vessels lying alongside. Clusters of piles should be placed near corners to protect them. The corners of wharves for large vessels should be rounded and strongly reinforced. To increase the life of a wharf, all joints and bearings must be treated with a preservative. Drift bolts should be driven below the tops of the timber, and the hole thus formed filled with tar or asphaltic cement. Large washers should be used under all bolt heads and nuts. You must be careful not to tighten the bolts too much or you'll break the outer wood fibers. When wood pieces are in contact, force them into closer contact with nuts and bolts to keep the water out.

BUILDING A TYPICAL ADVANCED BASE TIMBER PIER

Some of the details of a standard plan for a timber pier 40′ wide, are shown in figure 16–9.

The bearing piles, indicated as *A's*, must be driven first. Of course, the surveyor will determine the location of each pile for you. After the bearing piles have been driven, you'll have to cut the heads of the piles at exactly the same level so the cap sill will have an even bearing on all piles.

Cutting piles to the same height is simple. Just mark the correct height on the two outside piles of the pier. Then nail battens which have straight upper edges and are long enough to reach across the pier on each side of the piles. With the battens for a guide, use a crosscut or chain saw to cut the piles.

Batter piles, shown as *B's*, should then be driven. They are cut to the same height in the same manner as bearing piles. The cap sills, *C's*, are fastened to the top of the bearing piles by drift pins. These caps are of 12″ x 14″

material. Batter pile caps, *D's*, are placed as shown in figure 16–9. Then the batter piles are secured to these caps. Notice how batter pile cap blocks, *E's*, are bolted to the cap sill so as to strengthen the batter pile caps against which the batter piles rest. Transverse pile bracing, 3″ x 10″, is installed as indicated in the figure by *F's*. Longitudinal bracing, 3″ x 10″, made fast with bolts to the bearing piles as shown, is designated by *G's*.

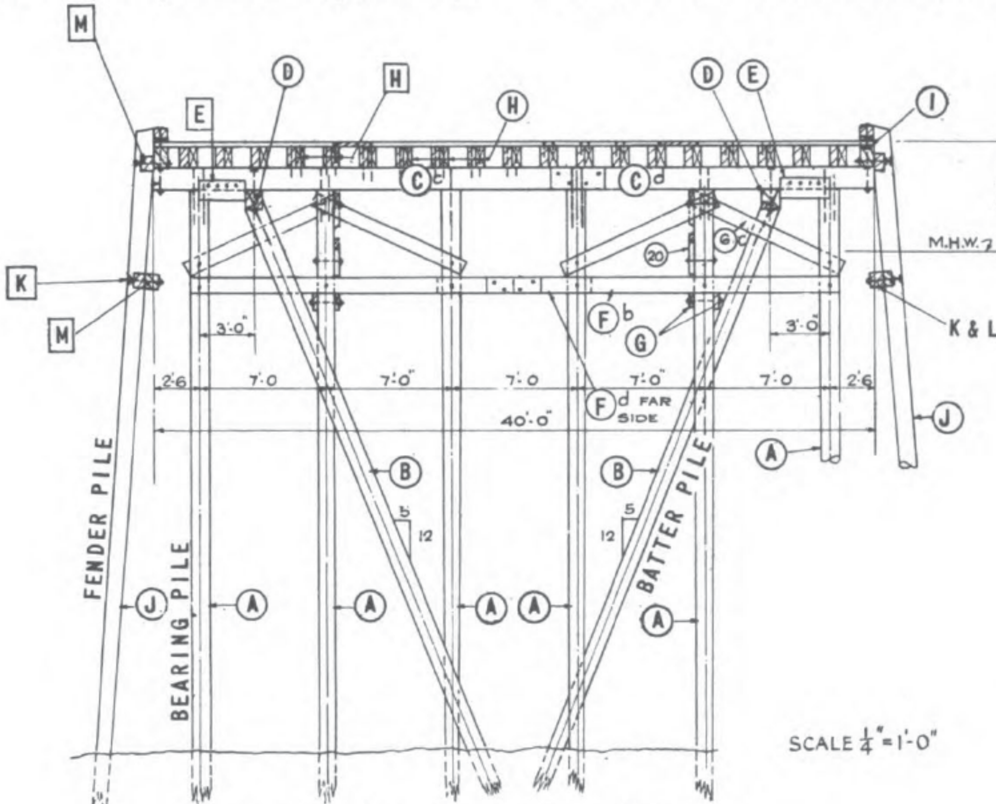


Figure 16–9.—Cross section—timber pier.

Stringers, or deck joists, 6″ x 14″, are then secured to the cap sills with drift pins. These structural members, *H's* in the cross section drawing, should be placed about 2 feet on centers. The two outside stringers, shown as *I's*, are of 10″ x 14″ material. The flooring or deck for the timber pier consists of 4″ x 12″ planking. It is laid perpendicular to the stringers or joists and should be fastened with boat spikes, countersunk at each joist. The joints in the flooring should be staggered and made over the joists.

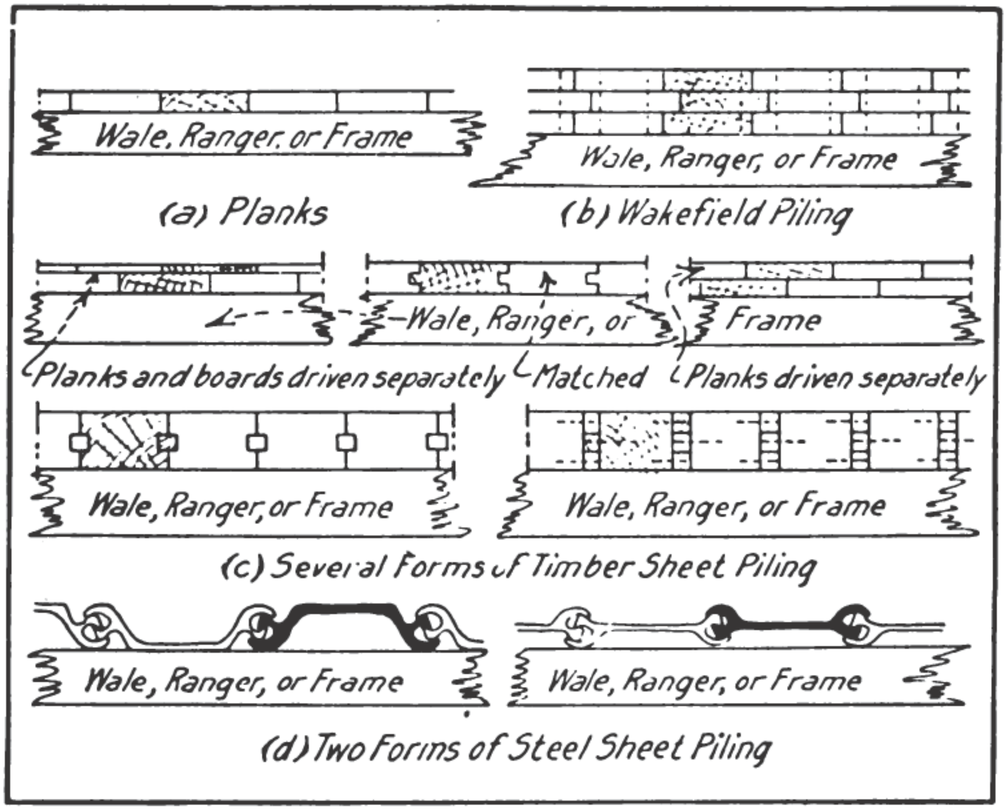
Your next job in building the 40-foot timber pier is to install the fender piles shown in figure 16–9 as *J's*. They are driven in vertically, and are bolted to the outside stringers. You'll notice that the fender piles are pulled over slightly as you make them secure. Fender wales, *K's*, are fastened to the fender piles as indicated. The wales are spliced with fender wale splices of 4″ x 12″ x 3′ material. The splices are shown in the drawing as *L*. 8″ x 10″ timber chocks should be bolted to the wales and outside stringers between the fender piles as illustrated by *M's*. You should fasten curbs, of 8″ x 10″ material, to the outside stringers as shown in the figure.

COFFERDAMS AND CAISSONS

A COFFERDAM is a water-tight enclosure from which the water is pumped to expose the bottom of the river or sea so you can work there. It was by constructing an oval cofferdam that we were able to examine the sunken battleship *Maine*.

CAISSONS are boxes or chambers used for construction work under water. There are three forms of caissons used in constructing foundations under water: the box, the open, and the pneumatic. If the structure is open at the top and closed at the bottom it is called a box caisson. If it is open both at the top and bottom it is an open caisson. BUT, if it is open at the bottom and closed at the top, and compresed air is used, it is a pneumatic caisson. It is sometimes difficult to distinguish between a cofferdam and a caisson. In general, if the structure is self-contained and does not depend upon the surrounding material for support, it is a caisson. However, if the structure requires support such as sheathing or sheet piling, it is a cofferdam. Retaining walls and piers may be built of boxes of wood, steel, or reinforced concrete, floated into place and then filled with various materials. These are known as floating caissons.

Cofferdams and open caissons may be constructed of wood or steel sheet piling. The simplest form of wood-sheet piling consists of wood planks driven side by side as shown in figure 16–10A. This structure will hold back



Courtesy of John Wiley and Sons, Inc.

Figure 16–10.—Types of sheet piling.

earth, but it will not keep out water. The most common form of wood-sheet piling used in waterfront operations is the Wakefield piling, illustrated in figure 16–10B. It consists of three planks spiked together to form a tongue and groove. Other forms of wood-sheet piling are shown in figure 16–10C. With the exception of the simple planks, all the forms are intended to keep out water as well as to hold back earth. Various forms of steel-sheet piling are shown in figure 16–10D. If wood-sheet piling is used, the cofferdams and open caissons should preferably be square or rectangular in section. But, if steel piling is used, a circular section will give good results. Wakefield piling will stand the impact of drop hammers. However,

steel-sheet piling is usually driven with steam or air hammers. Light wood-sheet piling is sometimes driven with heavy wood mauls.

TERMITES AND TEREDOS

You'll sometimes see parts of a wooden structure break or collapse, even though from the outside they appear perfectly sound. When you examine the faulty section you'll usually find that the inside is honey-combed and eaten away. If this is the case, the villain is probably the TERMITE or one of his sea-going cousins, such as the TEREDO.

There are two principal classes of termites, wood dwelling and ground dwelling. The first kind eats his way into exposed wood and stays to raise a large, hungry family. The second kind enters into wood which is in contact with the ground, or constructs covered tubes so he can get to the wood without coming out into the open. This last type causes most of the damage.

To protect your structure against the wood dwelling termite, you should treat the wood with coal-tar creosote or with chemical salts. A good coat of paint will give additional security. Ground dwelling termites are discouraged by treated wood, but you should also take other precautions. These consist of installing continuous metal shields so the termite can't eat his way through, or of using concrete foundations to keep the wood from contact with the soil. You should inspect foundations regularly for signs of covered runways. If the runways are destroyed, any termites in the structure will die, provided they haven't found their way into damp wood. Wood kept wet by water leakage will support ground dwelling termite colonies even though their path to the ground has been cut off.

You may not have much trouble with termites, but around the waterfront you're pretty sure to find yourself engaged in a TEREDO war. Nature has equipped these little

sea creatures with special boring shells on their heads. The teredo attaches himself to the surface of the wood and starts boring. As soon as he gets well inside, he makes a right angle turn and starts up the inside of the wooden material. He can chew himself a tunnel as big around as your finger.

The teredo is just one of a number of marine borers. Another is the Limnoria which likes to operate on piling and bracing of piers. He burrows along the surface of the wood. The best protection against him, or any other borer, is a heavy creosoting treatment. In special cases you can cover your piling with metal or concrete caps.

SAFETY PRECAUTIONS

Water front construction keeps you on your toes all the time. Make it a habit to think safety, to wear protective clothing, and to use the safety equipment required for the type of work you are doing. Always wear life preservers when you're working over water. That is, unless proper scaffolds, platforms with guard rails, or safety belts and life lines are provided. Use only equipment and machinery that has been inspected and approved. Don't forget your gloves and goggles when you have to handle timber treated with creosote. Fumes from creosote are hard on your eyes.

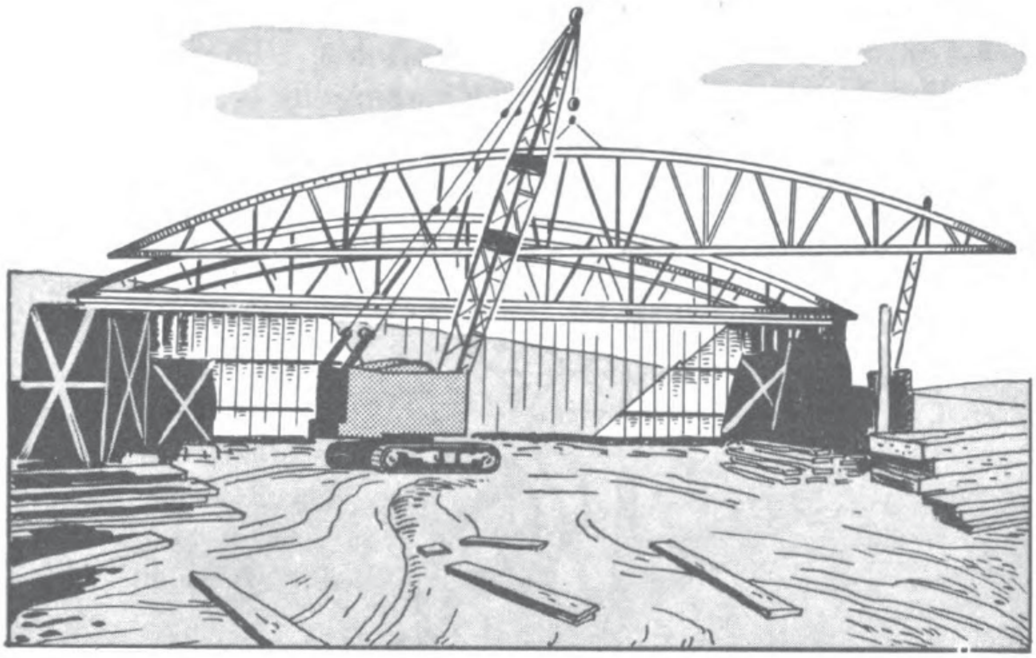
Before drilling through piling, make certain that a shipmate isn't leaning against the other side. Don't hitch rides on loads, hooks, hammers, material hoists, or buckets. Those are risky means of conveyance at best.

When you store or remove piles, handle them at the ends. Watch out for rolling piles and timbers. Stay clear of the center of the piles. Be sure to take the top pile when you need one. Walking on piles or timbers stored for use may get you to a destination you hadn't anticipated.

When you receive storm warnings, be sure to move all loose material from waterfront structures, or batten it down securely.

QUIZ

1. What is a quay?
2. What is the method you'll generally use to build a quay or bulkhead?
3. You'll find piles used in the construction of nearly all types of waterfront structures. Name the six groups into which these members are classified in accordance with their structural purpose.
4. What is a dolphin?
5. What are sheet piles?
6. If the pile is driven in water, how is its location determined?
7. When it is necessary to drive a pile below the leads, what should you use?
8. How should you protect steel sheet piles when the piles are to be pulled and re-used?
9. When driving sheet piles for a cofferdam, you'll first place them all the way around. Then you'll work them down gradually. What is this method called?
10. How is a template or guide made in order to assist you in driving the steel sheet piles in a straight line?
11. Why should you check by every means available in order to determine if the first pair is vertical?
12. Why should the front wall bulkhead be anchored back to the rear wall anchorage, called the deadman?
13. When is it necessary to build relieving platforms?
14. What are the two principal classes of termites?
15. What is the best protection against marine borers?



CHAPTER 17

RIGGING AND ASSEMBLIES

You know how to do the rigging necessary for transporting logs by the overhead or cableway method over swamps, deep gorges, or steep, rocky sections. And you are now familiar with the rigging necessary for handling heavy timber and piles that are used for the structural members in the building of water front structures. The *Boatswain's Chair* is another job in rigging. It is a private elevator used for trips to otherwise inaccessible places. You should be able to make one up yourself when necessary. That's an easy matter, as you can see from the sketch in figure 17–1. The chair is for one person only, and it can be lowered or raised by means of the falls upon which it is hung.

For similar types of work where two or more workmen are required to do the job, you'll use a *Swinging Scaffold* like the one shown in figure 17–2. It is somewhat like a double boatswain's chair but is suspended by two blocks and falls. So you see that rope and rigging assemblies are

important items in logging and water front operations, boatswains' chairs, and swinging scaffolds. Therefore, you must be familiar with rope and rigging in order to be a competent Builder.

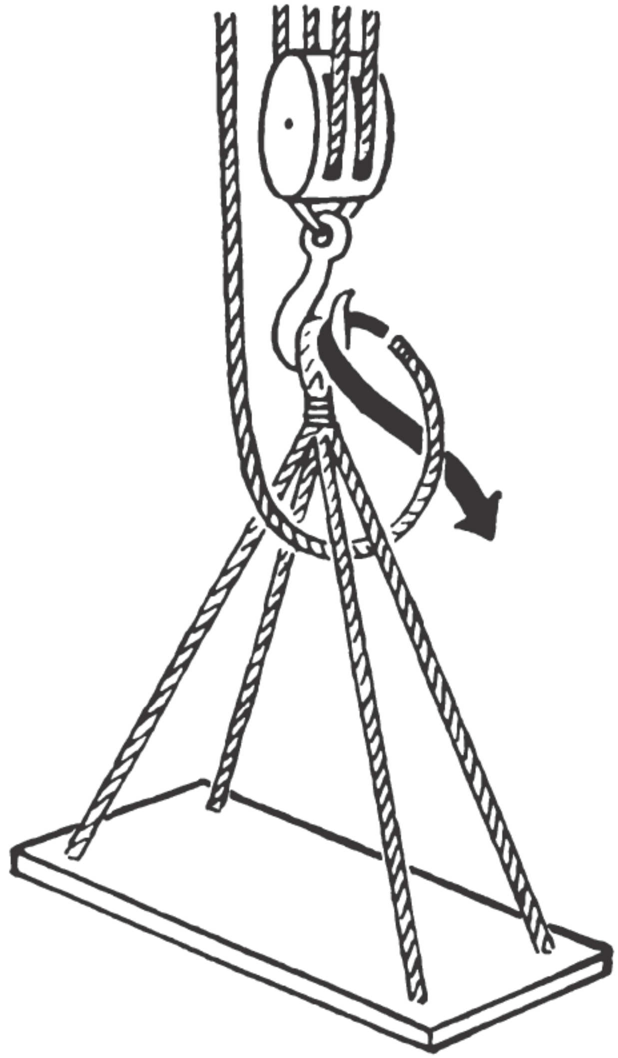


Figure 17–1.—Boatswain's chair.

HOW TO KNOW YOUR LINE

There are two general kinds of rope. One kind is made from vegetable fibers and the other from steel, iron, or bronze.

Manila, a strong and sturdy line, is made from the fibers of a banana-like plant grown in the Philippines. The best quality manila is creamy white, and is fine, soft,

and clean. The poorest grades of manila are dark brown. Thus, you can tell almost at a glance which is which. Manila rope comes in various sizes (see figure 17–3).

Another kind of fiber, not as good as manila, comes from a hemp plant grown principally in Russia, Hungary, and America. Your Navy uses hemp for small stuff—after it has been tarred. The tar makes small stuff last longer by protecting it from moisture.

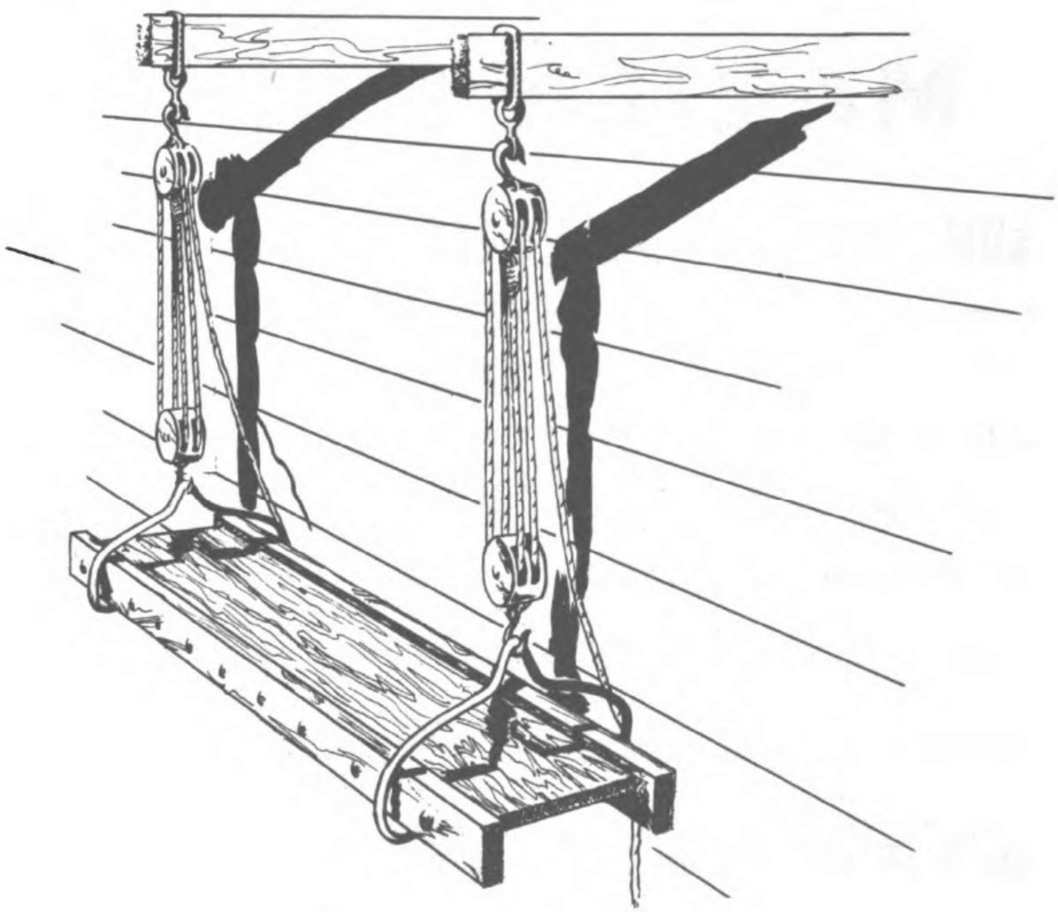


Figure 17–2.—A swinging scaffold.

Small stuff has a circumference of less than 2 inches and is designated by the number of threads (or yarns) that make up each strand. You may use 6 to 24 thread line, but that most commonly used is 6 to 21 thread. The small stuff you'll use for seizings is MARLINE. This is tarred, 2-strand, left-laid hemp. If you need something

stronger than marline, use a tarred, 3-strand, left-laid hemp called HOUSELINE.

LINE is anything over 2 inches in circumference. Its size is always designated by the number of inches around it. For instance, if your chief gave you a 6-inch manila line, you'd know it's made of manila and is 6 inches in circumference. Line ranges from 2 to 16 inches in circumference, 12 inches being about the largest carried in stock.

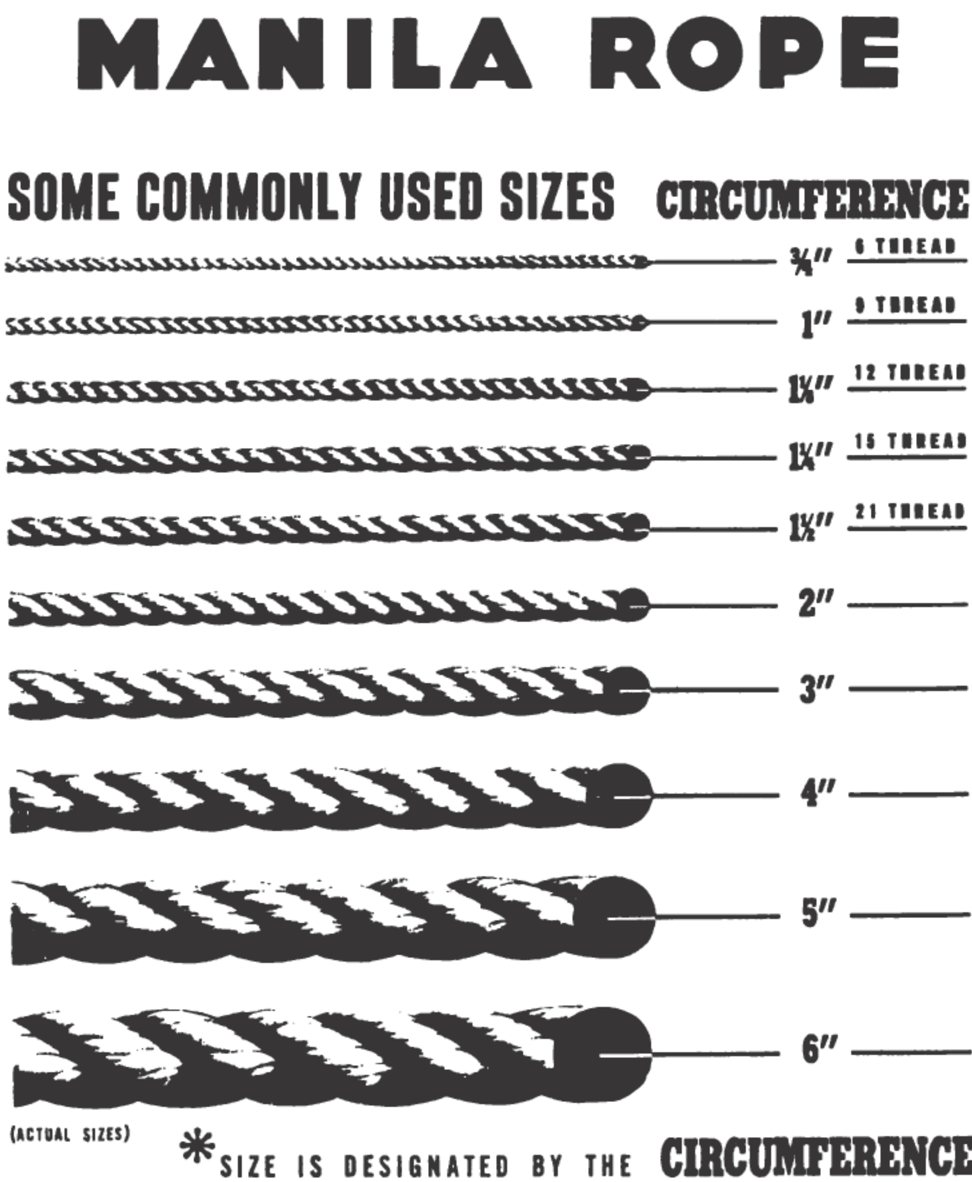


Figure 17-3.—Commonly used sizes of manila rope.

KNOTS are made by interweaving the ends of a piece of line. Knots are used to tie one line to another, or to a spar or ring. Remember, there's a certain kind of knot for every job.

Knots are made from two basic twists of your line, called BIGHT and ROUND TURN. The free end of any rope is just called the RUNNING END, and the rest of it is the STANDING END. Figure 17–4 shows you exactly what each

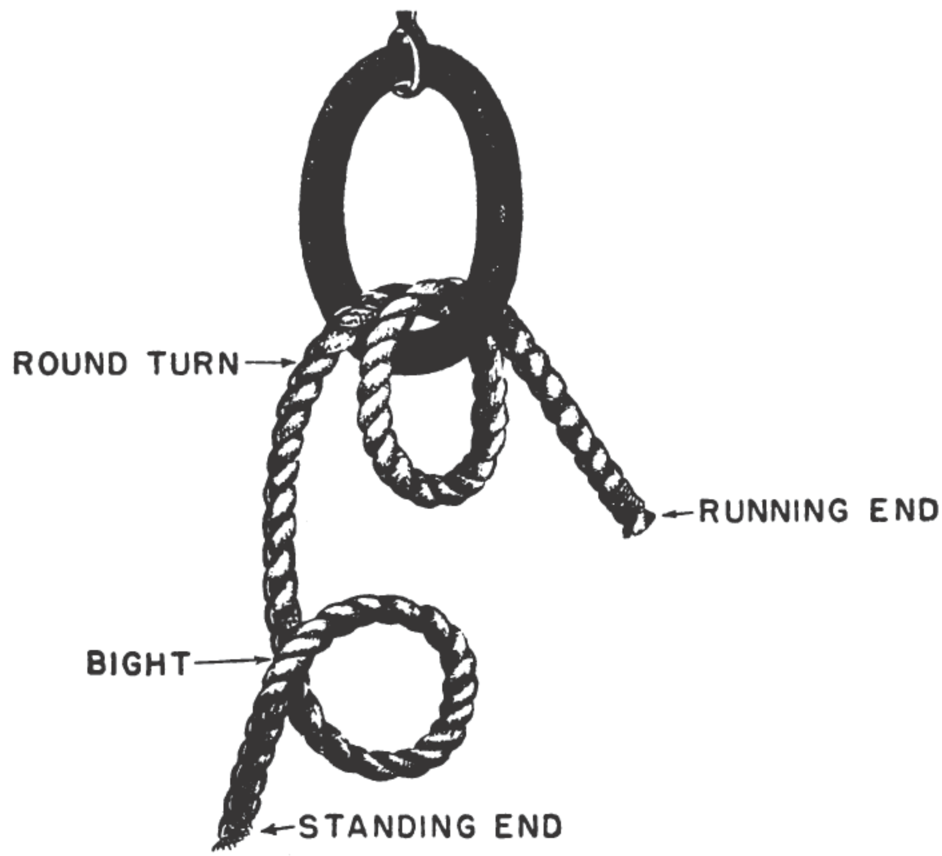


Figure 17–4.—Basic terms for handling fiber rope.

Figure 17–5.—Overhand knot.

one looks like. BE SURE you know these terms. It'll make it easier for you to know your knots.

The knots you'll frequently use in building operations are the overhand, square, bowline, and the timber hitch.

An OVERHAND KNOT is used in making other knots. If you put the end of a line over the standing part and pull it through the bight, your knot should look like the one in figure 17–5.

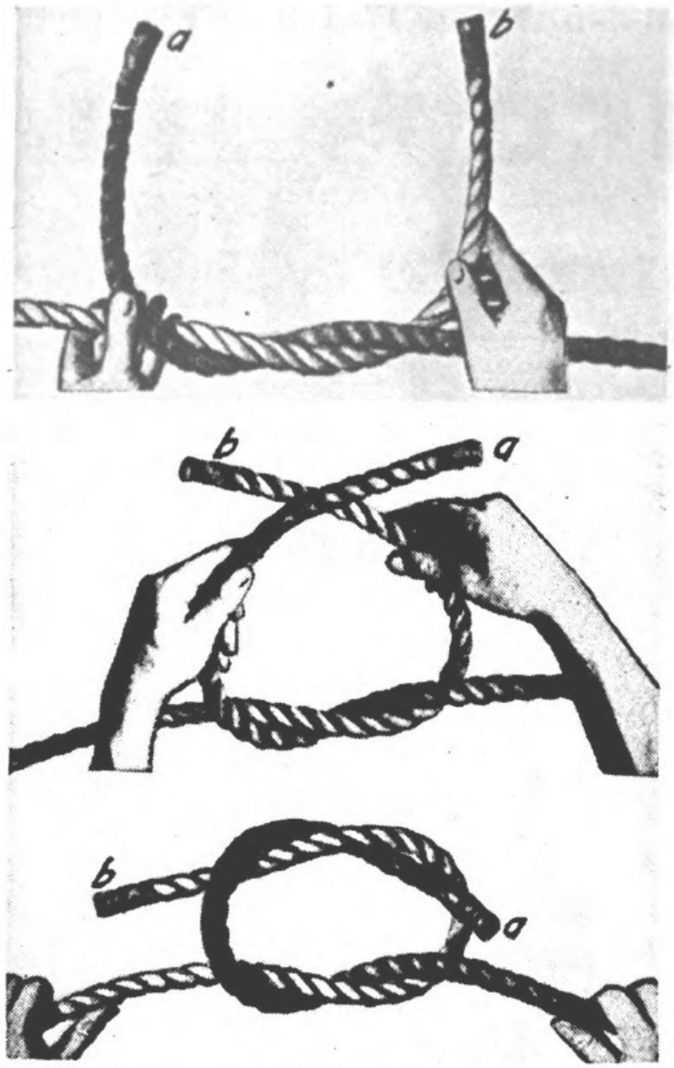


Figure 17–6.—Steps in making a square knot.

A SQUARE KNOT is used when you have to bend two lines together since it won't slip under a heavy strain. By following the steps shown in figure 17–6, you won't have a bit of trouble making one.

A BOWLINE is the kind of knot used if you want one which won't slip under strain, and yet can be untied quickly. With it you can make a loop any size. One way to make this knot is shown in figure 17–7.

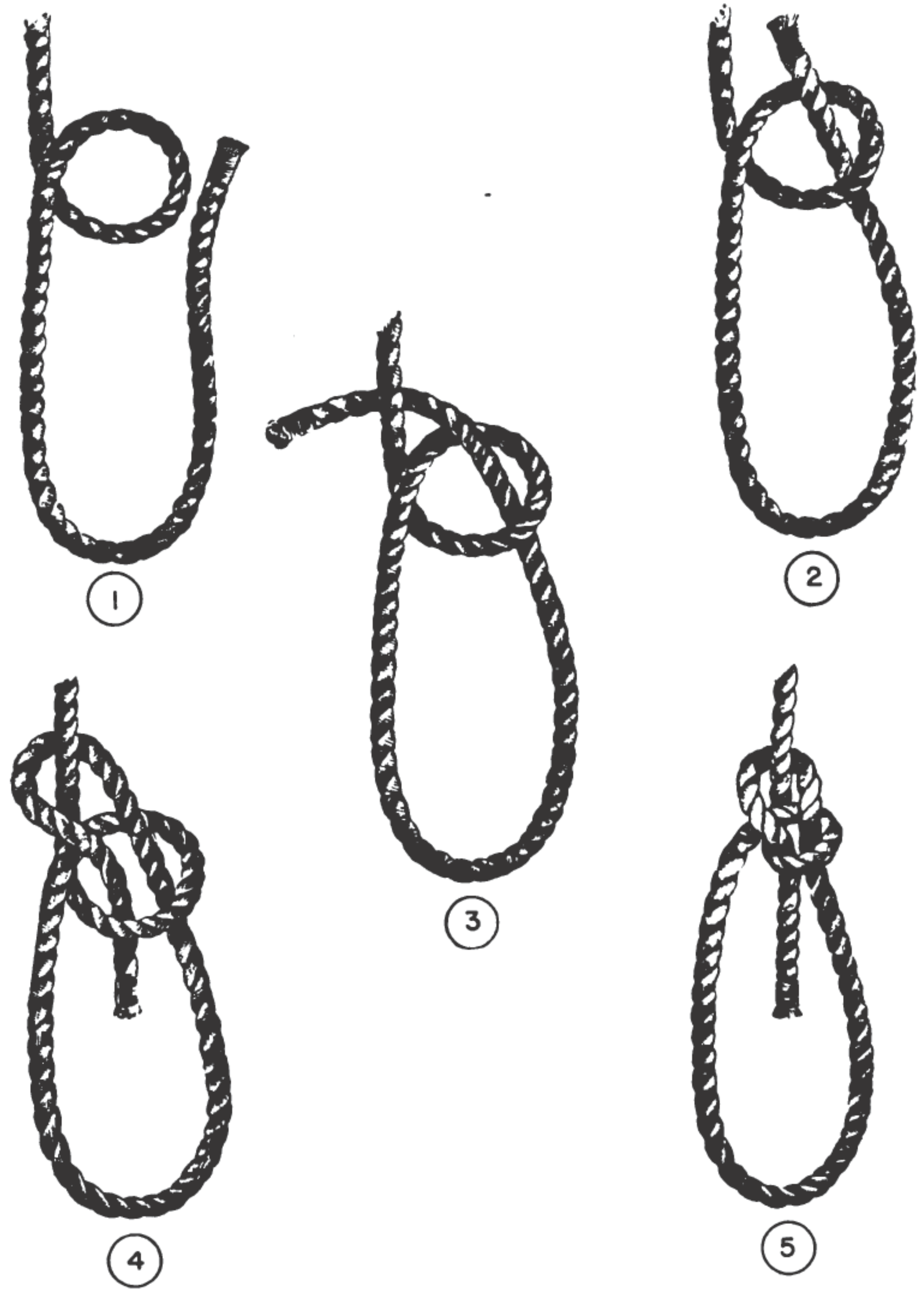
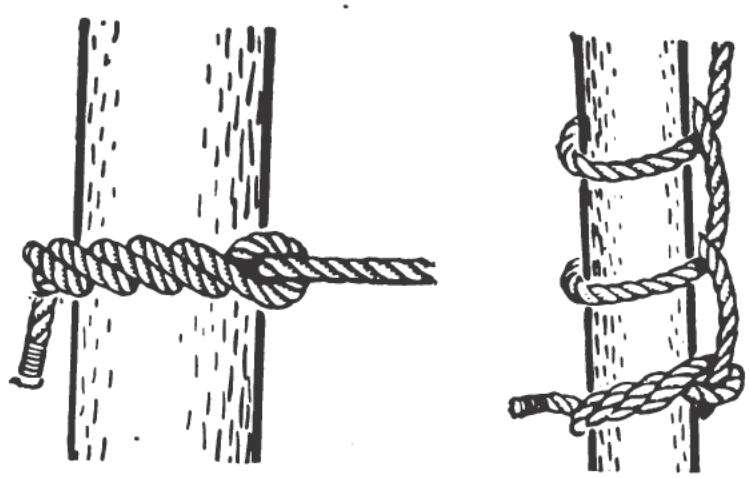


Figure 17–7.—One way to make a bowline.

The TIMBER HITCH is the most common hitch that you, as a Builder in the Navy, will use, due to its simplicity and the ease with which it can be made fast or untied.

The timber hitch is made by passing the line around an object and making a turn around the standing part. Then, as shown in figure 17–8, twist the line back on itself. Three turns back are sufficient, and they should be against the lay of the line.



Courtesy of Plymouth Cordage Co.

Figure 17–8.—Timber hitches.

Although there are many more, the two bends you'll come across most are the single sheet bend, and the double sheet bend (also called single and double becket bends).

A SINGLE SHEET BEND is used to join two different sized ropes. It's also good for tying wet ropes, or for tying a rope to an eye. You can be sure it won't slip or draw tight under light loads. You'll learn how it's done by studying figure 17–9.

A DOUBLE SHEET BEND is very much like the single sheet bend, except that it's better, and won't slip or draw tight under heavy loads. You start it the same way, but before you tighten the knot, you take one extra turn around both parts of the bight (see figure 17–10). Then, end it like the single.

When you know how to make a half hitch, round turn and two half hitches, clove hitch, blackwall, cat's paw, scaffold (called "stage" on shipboard), and barrel hitch,

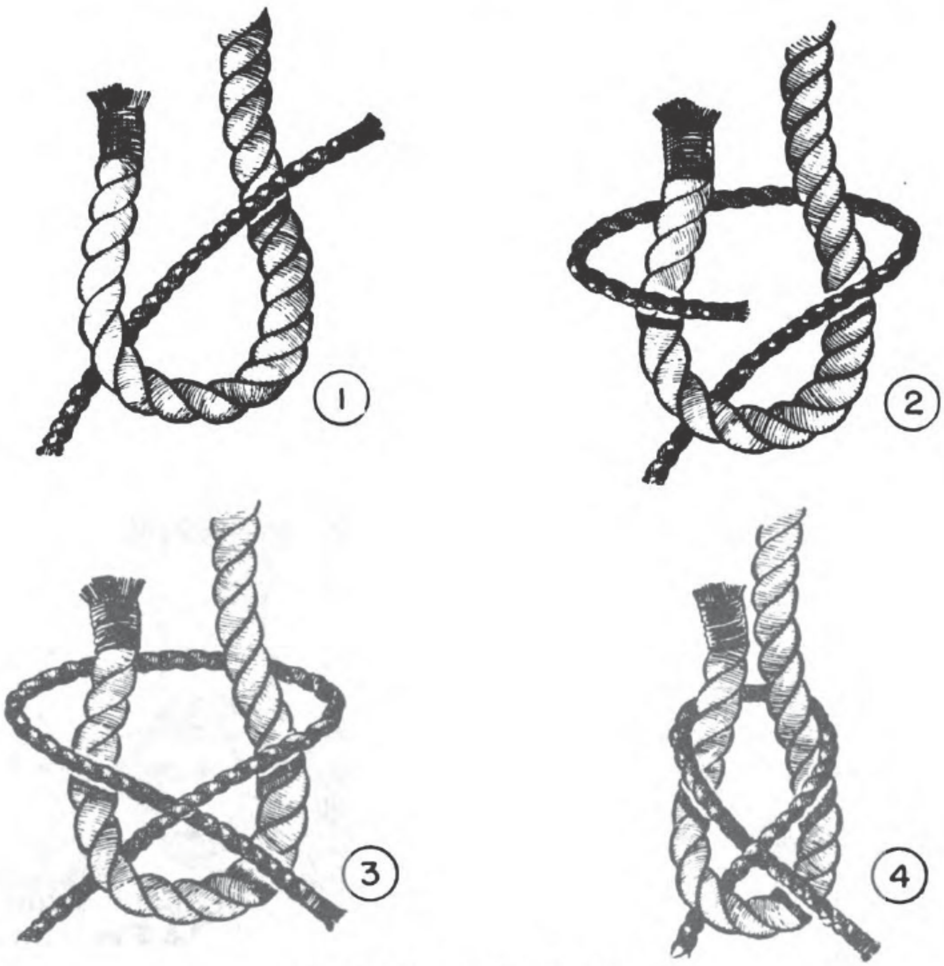


Figure 17-9.—Single sheet bend.

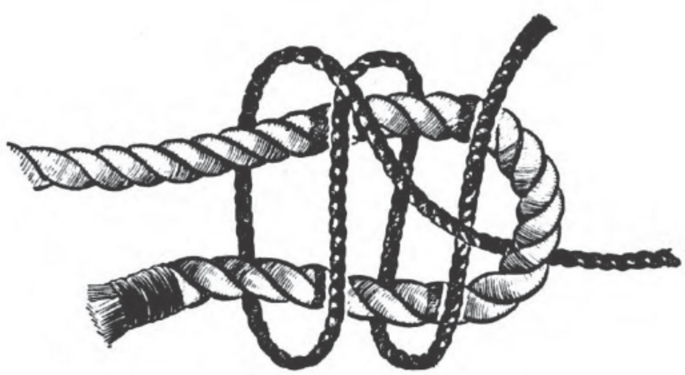


Figure 17-10.—Double sheet bend.

you won't lose any sleep over the other kinds of hitches.

A HALF HITCH is the basis for tying many other knots into line. Figure 17–11 shows you how simple it is.

A ROUND TURN and TWO HALF HITCHES is used to tie a line to a spar, or a post. Use figure 17–12 for your round turn, and figure 17–11 for your two half hitches. You should end up with a knot similar to figure 17–12.

Courtesy of Commonwealth of Pennsylvania.

Figure 17–11.—Half hitch.

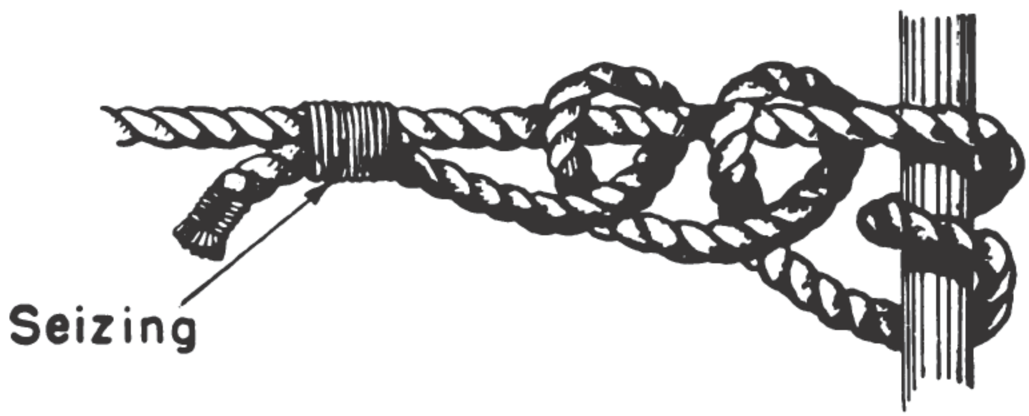


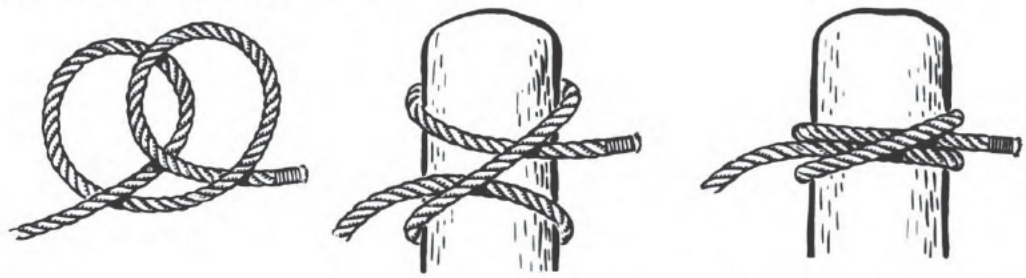
Figure 17–12.—Round turn and two half hitches.

To make this more permanent, you'll bind the end to the standing end with seizing. You'll make your seizing with a few turns of small stuff, and then finish off with a clove or some other hitch.

You'll like the CLOVE HITCH (see figure 17–13) for tying a line to a timber, pipe, or post, because you can tie it anywhere in your line. It's used to begin and end all lashings.

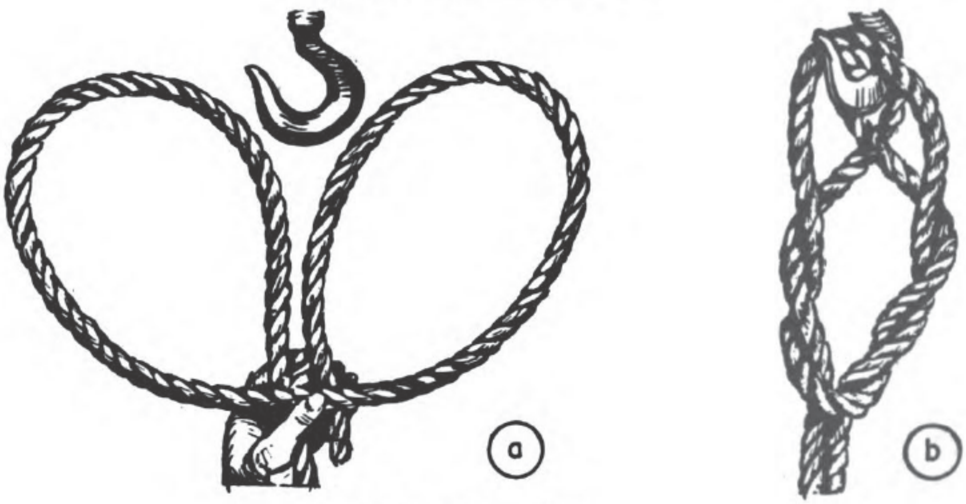
Use a CAT'S PAW, like the one in figure 17–14, to shorten your line when attaching it to a hook.

You'll use the SCAFFOLD or STAGE HITCH to lift a scaffold or stage board from the ground. Figure 17–15 shows you, step by step, how it's done.



Courtesy of Plymouth Cordage Co.

Figure 17–13.—Clove hitch.



① For endless sling.

② For end of rope.

Figure 17–14.—Cat's paw.

If you're going to lift a barrel, or other rounded object, you'll use the horizontal or vertical BARREL HITCH, as shown in figure 17–16, views *A* and *B*.

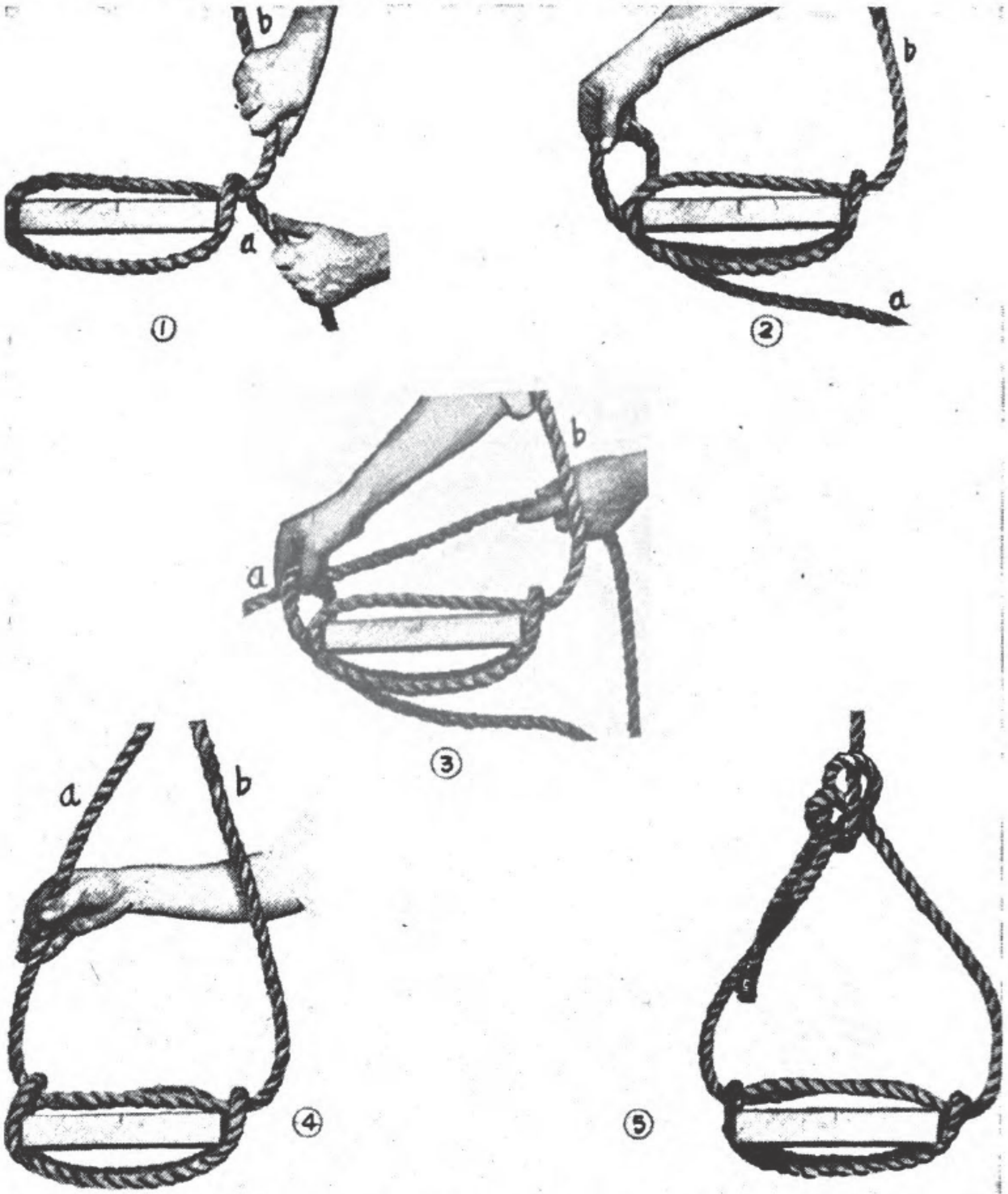
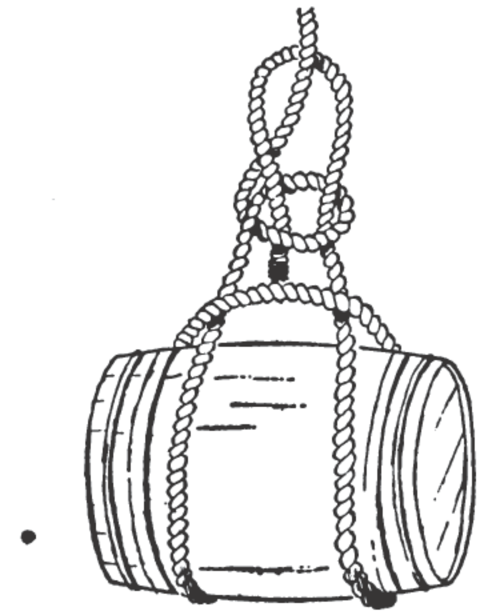


Figure 17–15.—Scaffold or stage hitch.

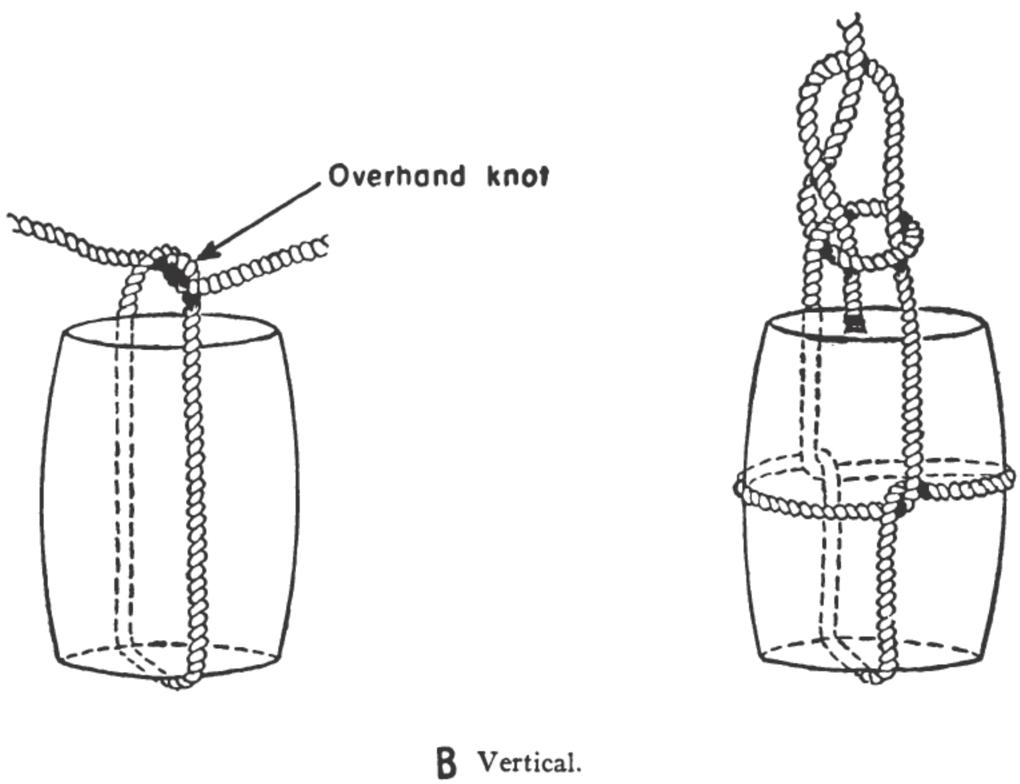
There are other knots besides the ones just mentioned. However, the ones shown in this chapter are the most important to you.

TAKE CARE OF YOUR LINE!

A good Seabee takes care of his line. If you handle, stow,



A Horizontal.



B Vertical.

Figure 17–16.—Barrel hitch. (A) Horizontal. (B) Vertical.

and figure its strength correctly, you'll not only save your material, but you and your shipmates will live longer. DON'T OVERLOAD YOUR LINE! First of all you must know the size of the line you work with, since you will have to figure how big a load it will SAFELY take. The size you'll consider is the circumference of your line. You've been saved a lot of figuring by the men in laboratories who have tried out the strains on line. These men have prepared an easy way to figure out the safe working load of any manila or hemp line, as long as you know its circumference. Just remember "C^2 x 150 lbs," and you can always find out how big a load your line will take. For example, suppose you had a line with a circumference of 3 inches. This is how you'd work it:

$$C^2 \times 150 \text{ lbs}$$
$$3 \times 3 \times 150 = 1{,}350 \text{ lbs}$$

But, you're not quite through yet, because all of this depends on the condition of your line. If it's fairly new, you'll add 30% of the 1,350 lbs. to get your safe working load of 1,755. If it's in bad shape, though, you'll subtract 30% from your 1,350 lbs. and get 945 lbs.

KEEP IT CLEAN! Don't drag the line over the ground, because it'll pick up sand and grit which will work into the strands and wear the fibers. If your line does get dirty, however, you can wash it with clean water.

Wire rope is different from line. Since it is man-made, its substance, form, size, and strength can be pre-determined. The substance used in making wire rope depends on how much strain it's going to take, how rough a job it has to do, and how well it can stand wear and tear and exposure to weather. Following are the most commonly used materials for making wire rope.

IMPROVED PLOW STEEL, since it is the strongest, toughest, and most resistant to wear, is mostly used for heavy duty service such as deep shafts and excavating machinery. Each square inch of it can stand strain from 240,000 to 260,000 pounds.

The differences of strength of manila line and wire rope are shown in the following table:

Number of Threads in Diameters of Manila Small Stuff	Diameter in Inches	Circumference in Inches	Weight in pounds per 100 Feet		Safe Working load in Pounds	
			Steel	Manila	Steel	Manila
	1/4	3/4	10	2	506	84
	3/8	1 1/8	23	4 1/2	1,139	190
	1/2	1 1/2	40	8	2,025	338
	9/16	1 11/16	51	10 1/8	2,563	399
	5/8	1 7/8	60	13	3,164	527
6	3/4	2 1/4	88	17	4,556	759
	7/8	2 5/8	120	24	6,202	1,034
9	1	3	158	28	8,100	1,350
12	1 1/8	3 3/8	203	40 1/2	10,252	1,709
15	1 1/4	3 3/4	250	46	12,656	2,109
21	1 1/2	4 1/2	365	64	18,225	3,038
	1 3/4	5 1/4	525	84	24,806	4,134
	2	6	632	115	32,400	5,400
	2 1/2	7 1/2	988	117	50,625	8,438

PLOW STEEL can stand strains from 220,000 to 240,000 pounds per square inch (p.s.i.) and is used for hauling, hoisting and logging.

MILD PLOW STEEL is not only tough, but pliable, which makes it suitable for cable tool drilling, since it can stand repeated strain and stress. It has the strength of from 200,000 to 220,000 p.s.i.

CAST STEEL ROPE is used if pliability is more important than strength. Its strength is from about 180,000 to 200,000 pounds p.s.i.

You'll be more apt to use *Traction Steel* on your sheaves and drums, because it wears a lot better than other types. It can stand strains from 180,000 up to 190,000 pounds p.s.i.

Iron is the weakest (100,000 pounds p.s.i.) and is soft compared to steel rope. It is only used on large sheaves and drums where it doesn't get much wear.

Stainless steel and phosphor bronze are used in making wire rope just for special jobs, so you won't have to worry about them.

END VIEW

All wire rope is referred to by the number of strands and wires in each strand around its core. So, if you hear "6 x 19," you'll know that it means a six-stranded rope, with 19 wires in each strand. Almost all wire rope is made of six strands. This number gives the best service for most jobs. Figure 17–17 shows some cross section views of wire rope.

Courtesy of American Chain and Cable Co

Figure 17–17.—Cross section views of wire rope.

FITTINGS

Fittings are attached to the ends of wire rope, so it can be easily connected to other wire ropes, chains, pad eyes, or heavy equipment. In figure 17–18 you can see the standard types. The kinds of fittings you use depend on the job you need them for, or what you're going to connect them to. For example, if you had to hoist an I-beam from ground level, you could use two wire rope slings made by splicing a thimble into the rope and then attaching a shackle to the thimble. A thimble in an eye splice helps to keep the wire rope from bending, thus making the rope wear longer. See (8) of figure 17–18.

CLIPS

Clips are often used in connecting lines or making eyes. These clips are made up from a U-bolt and saddle. The main thing to remember when applying these clips is to end up with the U-bolt on the DEAD END.

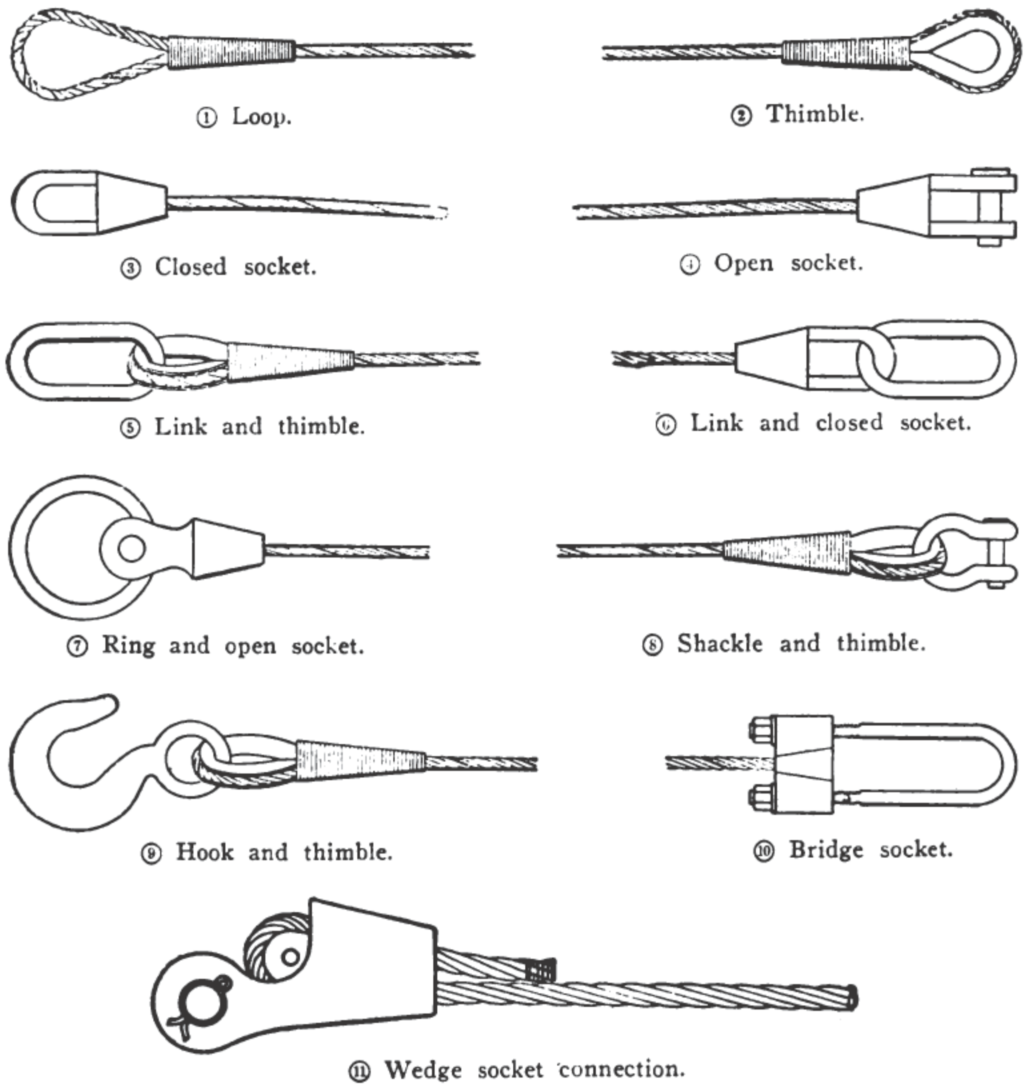


Figure 17–18.—Wire rope fittings.

The spacing for your clips should be at least six rope diameters apart for the surest hold on your rope. After the rope has been used, you should tighten the nuts, because loading makes your rope diameter get smaller by pulling on it. Now you'd probably like to know just how many clips to use. Well, all you have to do is figure

3 times the diameter and add 1. If your rope has a diameter of 1 inch, for example, you'll figure like this:

$3D + 1 =$ number of clips

$3 \times 1 + 1 = 4$ clips

If your figures end in fractions, ALWAYS use the next largest whole number. Now that you know how many clips to use, take a look at figure 17–19 to see how to attach them.

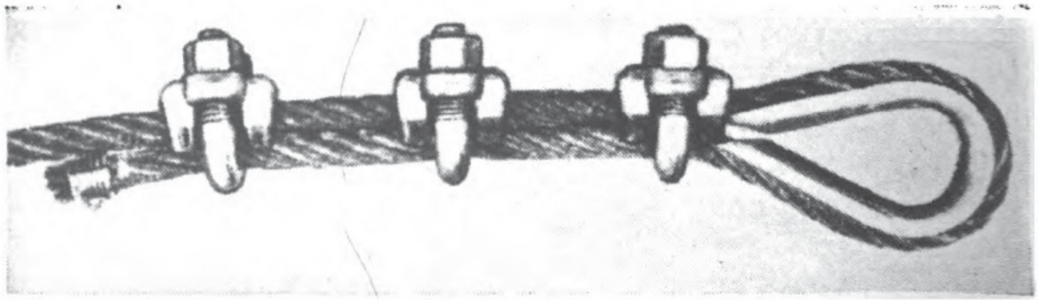


Figure 17–19.—The only way to attach clips.

BRAIN PLUS BRAWN

Weight lifting is a wonderful exercise for building muscles, and muscles are fine up to a certain point. But you'll discover that by using your brain as well as your brawn, you can find easier ways for lifting weights. Remember your BASIC MACHINES, NavPers 10624? It was full of sweat-saving ways of doing things. In handling material, you'll use blocks and tackle, slings, A-frames, gin poles, booms, and derricks to help you handle the heavy loads. All of these devices are variations of the basic machines—just common sense.

BLOCKS AND TACKLE

A block and tackle is a combination of lines and pulleys set up so you can pull from a convenient spot, and so you can hoist weights that you couldn't even budge otherwise. There are many kinds of tackle. The kind of tackle you'll use will depend on where, why, and how you're going to use it. Yet, they're all made up of just two main things that are always the same—that is, the line or wire rope and the blocks on which they are reeved.

In figure 17–20 you can see just what a block and its parts look like.

The *frame*, also called the shell, is usually made of metal, but sometimes you'll find one made of wood. It is the complete outer part of your block that supports one or more sheaves.

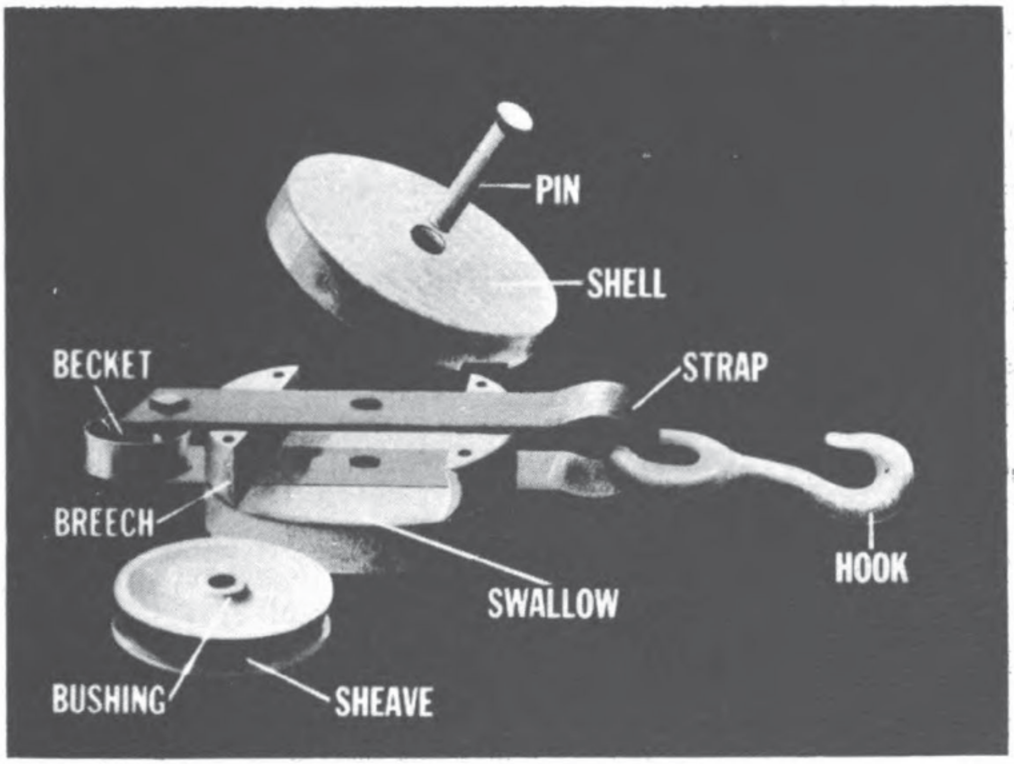


Figure 17–20.—A block and its parts.

A *sheave* is the wheel over which the rope passes.

The *pin* is a metal axle that the sheave turns on.

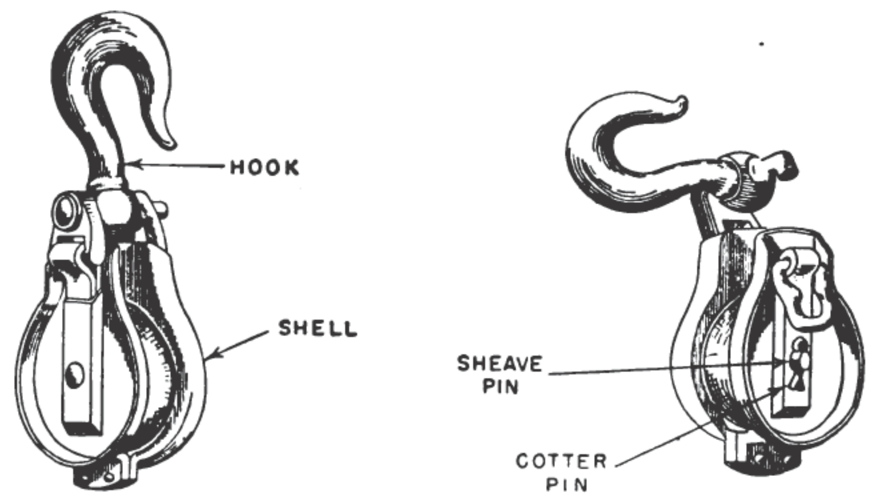
A *strap* is the metal part to which the hook and becket are secured.

The hole through which your line or wire rope passes is called the *swallow*.

The *breech* is the end of your block that is opposite to the swallow.

A *becket* is a metal loop formed at one or both ends of some blocks. You will fasten the standing part of your line to it to keep the line in place.

A block is named by the number of sheaves it has, such as the single, double or two-fold, three-fold, and the four-fold. Although the sheaves may vary in number, each block still has one of each of the other parts mentioned above, except the becket. Blocks may also get their names from their use, shape, or the places where they are needed.



SNATCH BLOCK (CLOSED) SNATCH BLOCK (OPEN)

Figure 17–21.—A snatch block.

The snatch block is about your most useful block in rigging. It can be used very well as a fairlead. (A fairlead is any fitting that preserves your line or wire rope and changes its direction so that the line or wire rope is delivered fairly to a sheave or drum.) With this kind of block, you can easily snatch your line on the bight at any point, since the hook is hinged on the shell and opens on one side. See figure 17–21.

Tackle by Any Other Name

Don't be puzzled if one of your shipmates call a combination of line and blocks a purchase—it's just another name for tackle. And when falls are mentioned, it's just one more name for your reeved line, wire rope, or tackle. The part of the fall that you'll secure to a becket is the

standing part, and the end that you'll apply force to is the hauling part.

By this time you probably know that with a purchase you can increase the pull several times over what it would be without a purchase. This increased pull, without any extra work on your part, is due to mechanical advantage. The easiest way to figure the mechanical advantage of a purchase is to count the number of falls above your *movable* block.

With a fixed block you won't get an increase in the amount of pull, because the mechanical advantage in this case is one. But, it does make a load easier to lift, since you can change the direction of your pull to a more convenient one by using a fixed block.

How Many Please?

The following purchases show how you can increase mechanical advantage by arranging blocks and tackle in a number of ways (see figure 17–22). The kind of arrangement you'll use on a certain job will depend on the weight you have to raise with the lifting force available at the time.

A *single whip* is a single fixed block with a line reeved through it, the end of which is secured to the weight to be moved. Since this is not a movable block, it doesn't increase the force applied, but does change the direction of the pull and makes hoisting easier.

A *runner* is a single movable block that is free to move along the line on which it is rove. This gives you a mechanical advantage of 2 to 1.

A *whip and runner* is a combination of one fixed and one movable block, giving a mechanical advantage of 2 to 1.

The *gun-tackle* is made up of one fixed and one movable block, with the standing part and the hauling part of your line leading from the same block. This tackle got its name by being used in the old days to train guns. Depending on which block is attached to your weight, you

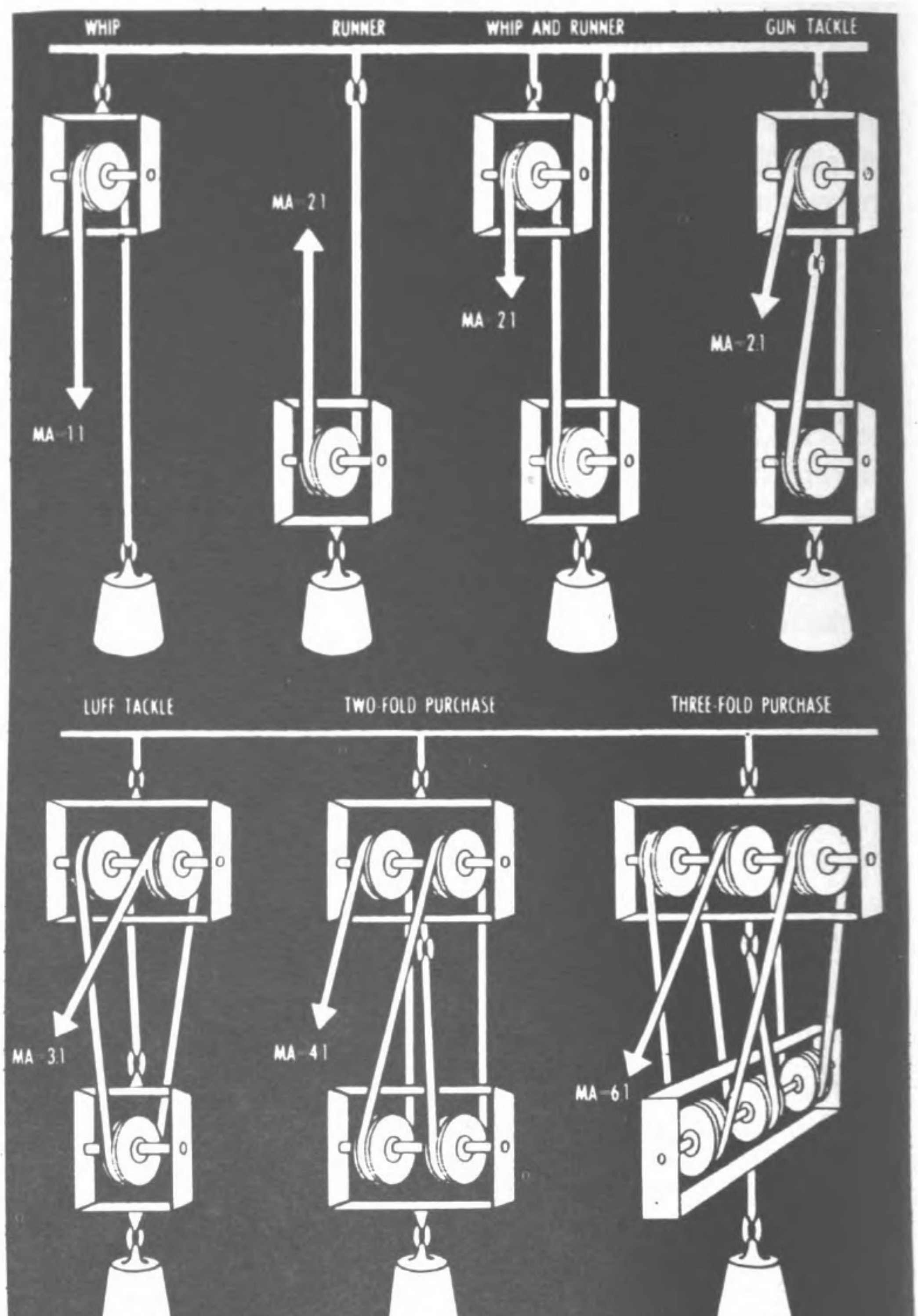


Figure 17–22.—The arrangement and mechanical advantage of various purchases.

can have a mechanical advantage of 2 to 1 or 3 to 1.

The *luff tackle* is one of the most useful tackles. It calls for a single and a double block. The standing part of the fall is made fast to the becket of the single block, rove through the double block, back through the single block, and back again through the second sheave of the double block. When you attach the single block to the weight to be lifted, your mechanical advantage will be 3 to 1. You can increase the mechanical advantage to 4 to 1 by attaching the weight to the double block.

For a *two-fold purchase* you'll need two double blocks. The standing part of the fall is made fast to the becket of the block from which the hauling part comes. The mechanical advantage can be either 4 to 1, or 5 to 1, depending on the block to which the weight to be moved is attached.

A *three-fold purchase* is about the heaviest tackle you'll use. Make the standing part of your line fast to the becket of one of the two triple blocks. The hauling part comes from the same block to which the standing part is tied. You'll have a mechanical advantage of either 6 to 1 or 7 to 1, depending on which block is attached to the weight to be moved.

SAFETY FIRST!

In hoisting, lowering and scaffold work, *safety first* should be the pass word. This should include safety for men and material.

1. Always check the blocks and sheaves when you get them from the rigging loft to see that the lines are in good shape and show no extensive wear at any one place.

2. Be sure that the blocks are properly greased.

3. Be sure that the line is the proper size for the job.

4. Be sure that you have enough mechanical advantage, in the amount of blocks, to make the load as easy to handle as possible and that the blocks are not twisted when you use them.

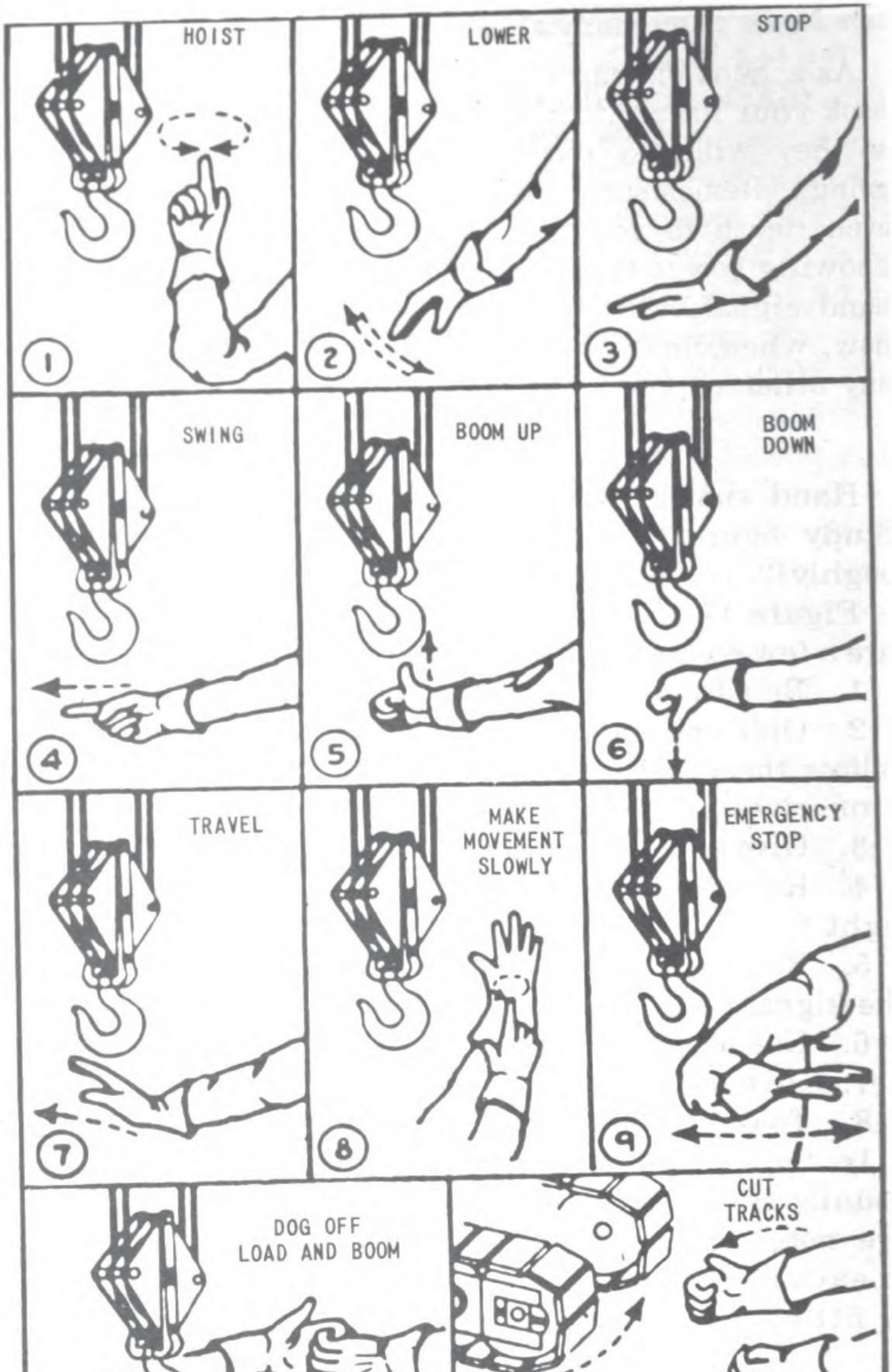


Figure 17–23.—Standard hand signals.

HOOK-ON MAN

As a hook-on man you will be expected to know how to hook your lines onto loads, or to sling your loads properly so they will stay put until they reach where they are going. Remember, one little slip may mean injury or even death to you or one of your shipmates. Besides knowing how to hook-on, you must also know the standard hand signals used to tell the operators of hoists what, how, when, and where. And this is just as important as any other part of your work!

Hand Signals

Hand signals keep you from yelling your lungs out. Study figure 17–23 until you know your signals thoroughly!

Figure 17–23 just shows you the hand signals, so here are a few pointers to go with them.

1. Be sure you KNOW your signals.
2. Only one man gives the signals, and the other men follow them. The one exception to this is an EMERGENCY STOP given by ANYONE. It must be obeyed.
3. Give all hand signals CLEARLY.
4. Remove gloves before signaling, unless they're a tight fit.
5. Be sure all men are clear of the load before you give the signal to hoist or lower away.
6. Use flashlight to signal when working at night.
7. Give ONLY the necessary signals.
8. To control the swing of the load use a tagline.

In the rigging loft, slings are made in many lengths, usually from about 6 to 50 feet. Here, wire rope lengths are noted by the use of a color code, which may differ in each loft. Each wire rope sling is painted at the splice or fitting.

LINE AND WIRE ROPE SLINGS

Each type of fitting forms a different type of hook-up. You can even make a hook-up with eyes in the ends of

your line or wire rope. The fitting you'll use will depend on the size, weight, and shape of the load to be hoisted. Remember to use the sling best suited for your load, and you'll be safeguarding yourself, your shipmates, and the materials.

HOLD THAT LINE!

When a crane isn't available, you'll set up and use such temporary rigs as gin poles, A-frames, and derricks. But before you can construct these, you have to know how to assemble several different kinds of anchorages. These anchorages do the job of keeping a SURE hold on the guys of the rigs.

GUYS are lines or tackle for keeping your rig steady and in place, or for swinging a boom. On rush field jobs, the best and quickest way to anchor your guy lines is to secure them to trees or stumps. Be sure to test the strength of these natural anchors BEFORE you use them—you can't take anything for granted. If there are no trees or stumps in your area, or if they aren't dependable, you'll have to construct your own anchorages. The use of the steel or wood picket holdfast and combination picket holdfast will depend on the kind of ground into which they are set and the amount of weight they must hold.

To make your anchorages as strong as possible, remember one thing: Drive each picket into the ground so it will slant opposite the pull, forming an angle of not more than 75 degrees between it and the ground.

For the single picket holdfast, you'll need a steel or hardwood picket, about 3 inches in diameter and 5 feet long, which must be driven about 3 feet into the ground at a 15-degree angle. To secure your guy to the picket, it's a good idea to make a clove hitch around the picket. This makes it much easier to get your line loose, than if you used some other knots. In undisturbed, loamy soil, this kind of holdfast is strong enough to stand a pull up to about 700 pounds.

To get more holding strength, you can use combinations of picket holdfasts. These are like the single picket holdfast, except that for a 1-1-1 combination, you drive three pickets into the ground, 3 to 6 feet apart, in line with the guy. For a 3-2-1 combination, you drive a group of three pickets into the ground, lashing them together before you secure the guy to them. The next group of two lashed

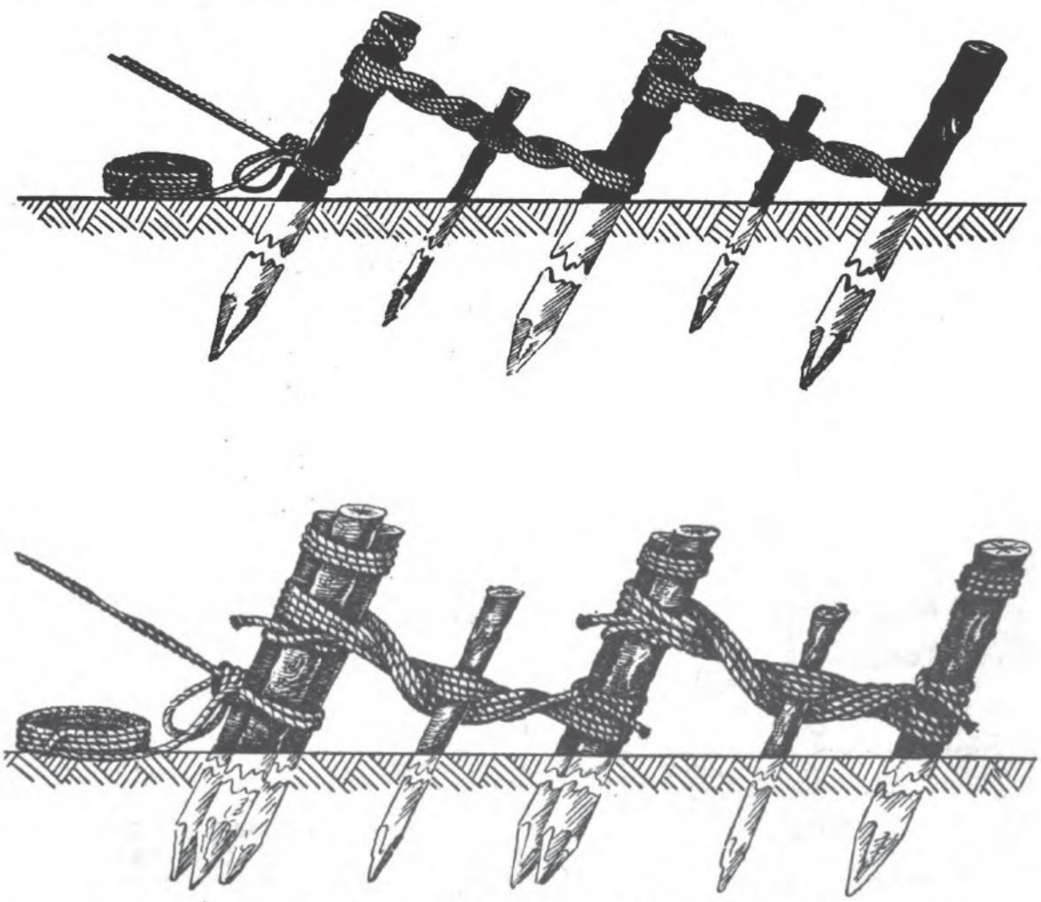


Figure 17–24.—The 1–1–1 and 3–2–1 combination picket holdfasts.

pickets follows the first group, 3 to 6 feet apart, and is followed by a single picket. The 1-1-1 combination can stand a pull up to about 1,800 pounds, while the 3-2-1 combination can stand as much as 4,000 pounds. (See figure 17–24.)

THE GIN POLE

This is a rig that you'll construct from a single pole, timber, or steel beam, held almost upright by guys. Loads

of medium weight can be lifted from 10 to 50 feet by the block and tackle supported on the gin pole. The hauling part of the tackle leads through a snatch block at the base of the pole to the source of power. Figure 17–25 shows you how a gin pole is erected and the details of the lashings.

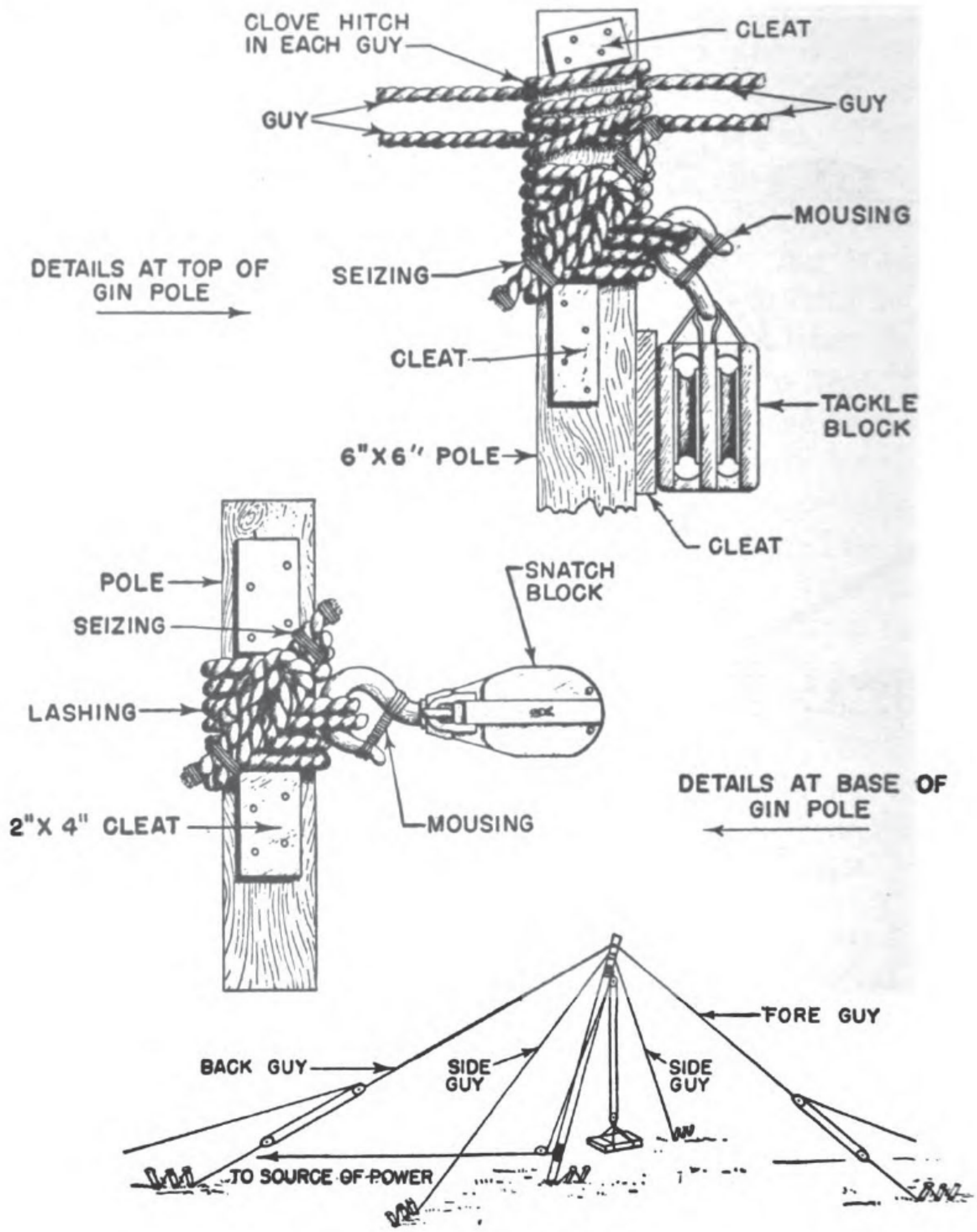


Figure 17–25.—The gin pole.

If one pole is too short and you have to splice two together, place the sections so that the end of one touches the end of the other. This is called BUTT SPLICING. Join the sections together by bolting wooden scabs or metal plates onto them. Sometimes you'll use large spikes to fasten the wooden scabs.

The gin pole should be no longer than 60 times its thickness. Otherwise it will buckle under a heavy load.

Anchorages for your gin pole guys should be placed at least twice the length of the pole away from its base, if the ground is level.

Stress is in the picture again! Only this time it's divided, because the gin pole has two aft guys. The angle of the pole makes a difference, too. For instance, if the pole is vertical, the stress on each aft guy is almost nothing. But, when the angle between the guy and the ground is 45 degrees, the stress on each guy is almost one-half of the total load. That's why you have to figure on using guy rope that will stand stress of at least one-half the load.

Rigging and erecting a gin pole can be done by the following steps:

1. Lay the base of the pole at the spot where you're going to erect it.

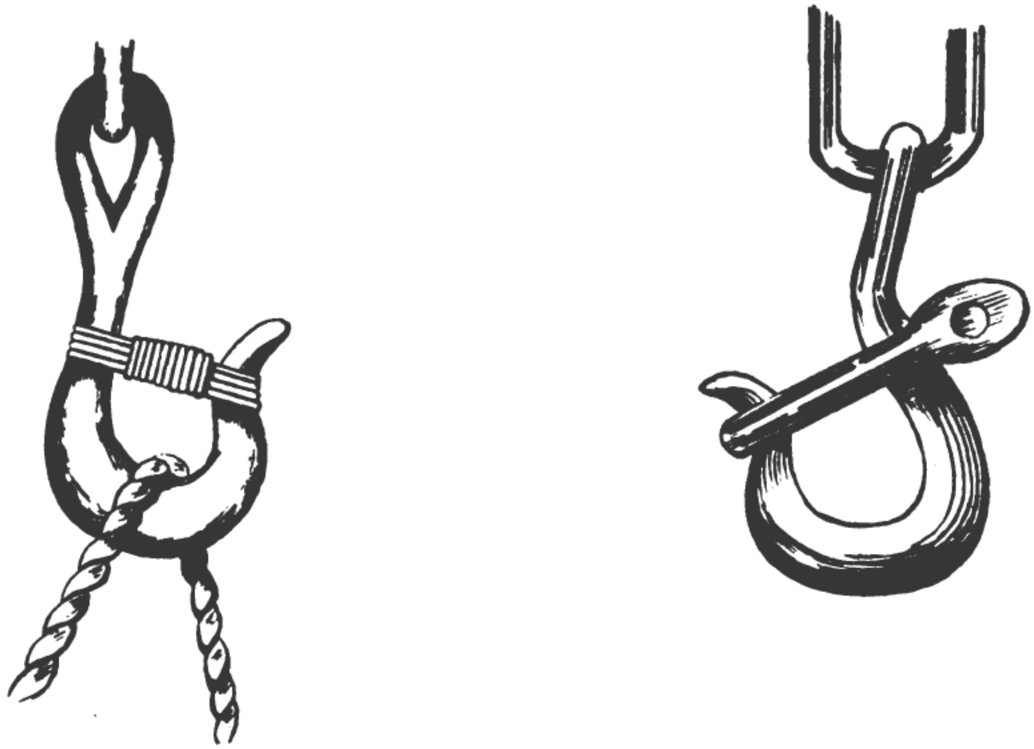
2. Make a tight lashing of about 8 or 9 turns, about 1 foot from the top of the pole, and secure the ends with a square knot. Nail cleats above and below the lashing to keep it from slipping. Now, slip the hook of the top block under at least two of the turns and mouse it. See figure 16-26.

3. Lay out guy ropes about 4 times as long as the pole. Each rope makes two guys by using a clove hitch in the center which is passed over the top of the pole above the tackle lashing. The guys lead from the pole, opposite each other, to the ground.

4. Make another tight lashing (as above) about 2 or 3 feet from the base of the gin pole, and put a cleat above this to keep it from slipping. This is where the snatch block is secured and moused, like the tackle block.

5. Now reeve your tackle so that the hauling part passes from the top block, through the snatch block, to the source of power.

6. To keep the pole from skidding while being erected, and to keep it in place while hoisting a load, you will have to devise a means of securing the base. One method is to place the pole on a 2 x 10 or a 2 x 12 plank that is long enough to allow diagonal braces from the pole to



(A) (B)

Courtesy of Commonwealth of Pennsylvania

Figure 17–26.—Hooks moused with wire, marline, or with a shackle.

the plank. Now place a plank directly back of the pole and brace the first to the second, forming a triangle base. This method will enable you to move the pole from one location to the other without having to fix a new base at each move of the gin pole.

7. Before erecting the gin pole, make SURE the lashings are properly made and hooks are moused.

8. A gin pole not longer than 40 feet can be erected

by hand, but longer poles must be raised by other means.

9. Lay out each guy as far as its anchorage. If tackle is not used on the aft guys, one man controls the slack of each, with turns around the anchorage as the pole is raised.

10. You can do one of two things to avoid having to shinny up the pole to bring the movable block down within reach. You can tie a line to the hook of the movable block, or, you should overhaul the tackle until it's longer than the length of the pole, and secure it to an anchorage opposite the base.

11. To raise the pole easily, start raising it by hand to about 3 or 4 feet from the ground and then round in the blocks of the aft guys. While raising the pole, keep tension on the fore guys. Otherwise the pole may swing and throw all the weight to one side.

12. When the pole is upright, make all guys fast with final half hitches of the round turn and two half hitches.

13. You can move the top of the pole from vertical to 15 degrees forward without moving the base. This is called drifting and should be done while the pole is not loaded, unless you can regulate the tension of all guys by tackle secured at the end of each. You'll drift the pole forward because the load should not touch the pole.

THE A-FRAME

You'll use an A-frame for lifting heavy timbers, trusses, columns, and beams. This rig is formed by bolting or lashing two timbers, poles, pipes, or steel bars together, near the top, to form what looks like the letter "A." Although the A-frame is the same, whether bolted or lashed, you may hear it called SHEARS or SHEAR LEGS (see figure 17–27).

After lashing the two poles at the top with 18 or 21 thread stuff, apply a frapping between the poles and around the lashing. Then pass line or wire rope between the "V" (at the top of the A-frame) and under it to form a sling. You'll secure your hoisting tackle to this

sling. Now tie a line to the hook of the movable block, so you can pull the tackle within reach after the rig is set up. Or, you can just overhaul the tackle.

Now you're ready to attach your guys—2 aft guys and 1 or more fore guys. Pass a clove hitch in the center of each guy wire, around the tops of both legs. If extra tackles are available, secure one near the bottom of each guy. Tackle makes it much easier when you have to tighten or slacken your guys. It'll help you to make aft guys taut and to slacken the fore guy, while the rig is being set up. And for taking down the rig, you'll be able

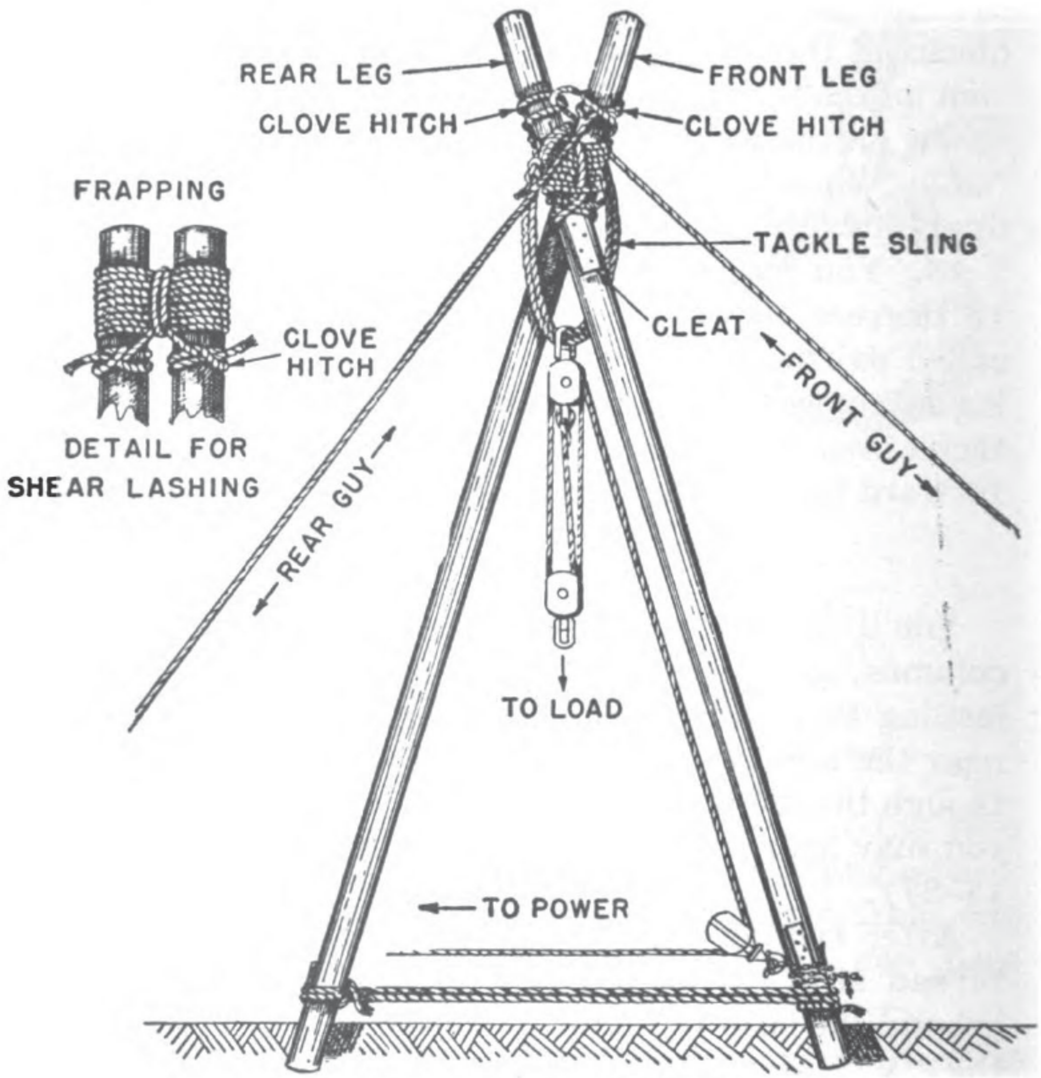


Figure 17-27.—Erection of an A-frame.

to slacken the aft guys much quicker by the use of this tackle. Of course, to adjust the drift, it's mighty handy to use tackle to tighten or slacken your guys. For handling the guys, there should be from 2 to 4 men on each aft guy and 1 man on the fore guy. Each of the aft guys must stand a stress up to as much as ½ the weight of the entire load. The fore guy doesn't have much strain on it. It does help when you want to adjust the drift of the A-frame, and keeps the top of the rig steady when you're moving a load.

Spread the poles apart, never less than ½ the height of the A-frame. Use the same base as on the gin pole. This will keep the legs from slipping while the rig is in use. After the A-frame has been raised, tie the legs together with a 1 x 6 or 2 x 6 inch board, about 1′ off the deck, to keep them from spreading farther apart.

Like the gin pole, the A-frame must be started upward by hand. When the rig is almost upright (about 5 degrees forward) secure all guys to their anchorages.

The shorter your timbers, the more stable they are. That's why timbers for light loads can safely be longer than the timbers used for heavy loads. By studying the table on the next page, you can see how the weights of loads vary according to the length of the timbers. The safe capacity of each leg of an A-frame must be figured at ⅞ the safe capacity listed. Although an A-frame can be drifted as much as 45 degrees forward while hoisting, there's more stress on its legs the further forward it has to be drifted. So, you have to make extra allowances for drift.

When using a truck-mounted A-frame, be sure to chock the wheels of the truck so it doesn't have a chance to move while in use. The drift on these truck-mounted A-frames can safely be a little more than 45 degrees, because they are usually constructed from pipe that is reinforced. The use of reinforced pipe gives such rigs greater stability.

Size, one pole (inches)	Length (feet)	Safe Capacity (tons)
6 x 6	20	5
	25	3
	30	1.5
8 x 8	25	7
	30	5
	40	3
	50	2
10 x 10	20	20
	25	15
	30	10
	40	6
	50	4
12 x 12	30	20
	40	12
	50	8
	60	6

DERRICKS

The boom derrick, swinging guy derrick, and stiff-leg derrick are the three most important to you as a Builder. Like tools, or other equipment, the derrick you'll use will depend on the job to be done.

The boom derrick, as shown in figure 17–28, is the most temporary type of hoist for light to medium loads, and can be set up the quickest.

The first step is to rig a gin pole, but add to it another block, lashed about 2 or 3 feet below the tackle lashing at the top of the pole. The fall line, in this case, should come from the movable block instead of the fixed block.

For your boom, select a pole, timber, steel pipe, beam, or laminated plank of the same diameter as the gin pole, but only about ⅔ its length. Spike 2 cleats to the butt end of the boom and lash them with small stuff to form a fork as shown in figure 17–28. This fork is for the purpose of keeping the boom from getting away from the gin pole (or mast) while moving a load from side to side. So, use cleats long enough to extend from the butt end

of the boom to beyond the mast. About 4 feet above where the boom meets, spike 2 cleats into the mast, and place a lashing of at least 4 turns of small stuff above the cleats, keeping two ends free.

Using a sling attached to the gin pole tackle, raise the butt end of the boom as high as you want it. With the

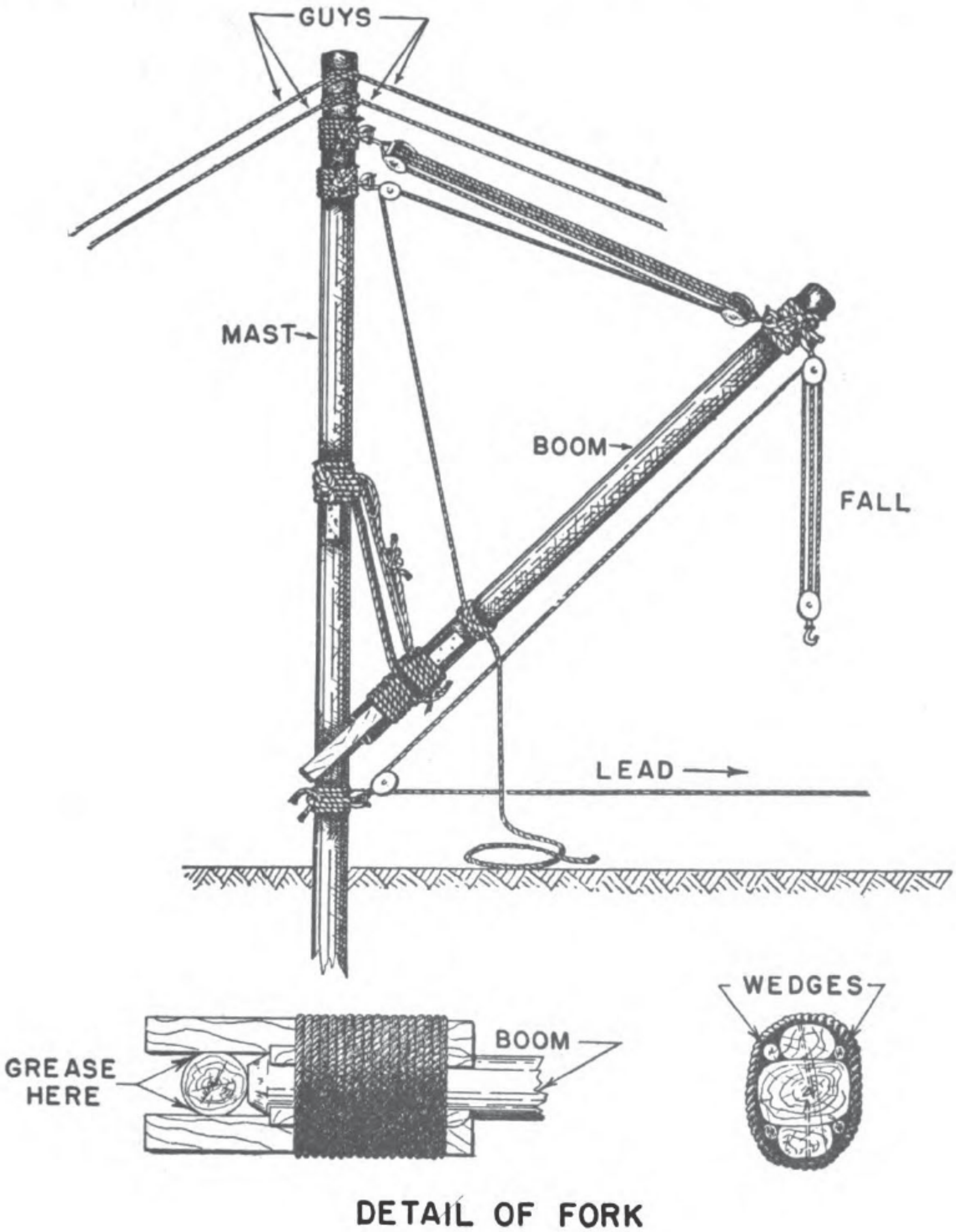


Figure 17–28.—Boom derrick.

free end from the lashing on the mast, make a sling to support the butt end of the boom.

Lash the movable block of the gin pole tackle to the top end of the boom, and lash the fixed block of the boom tackle at the same point. This tackle is reeved so that the fall line comes from the fixed block and passes through

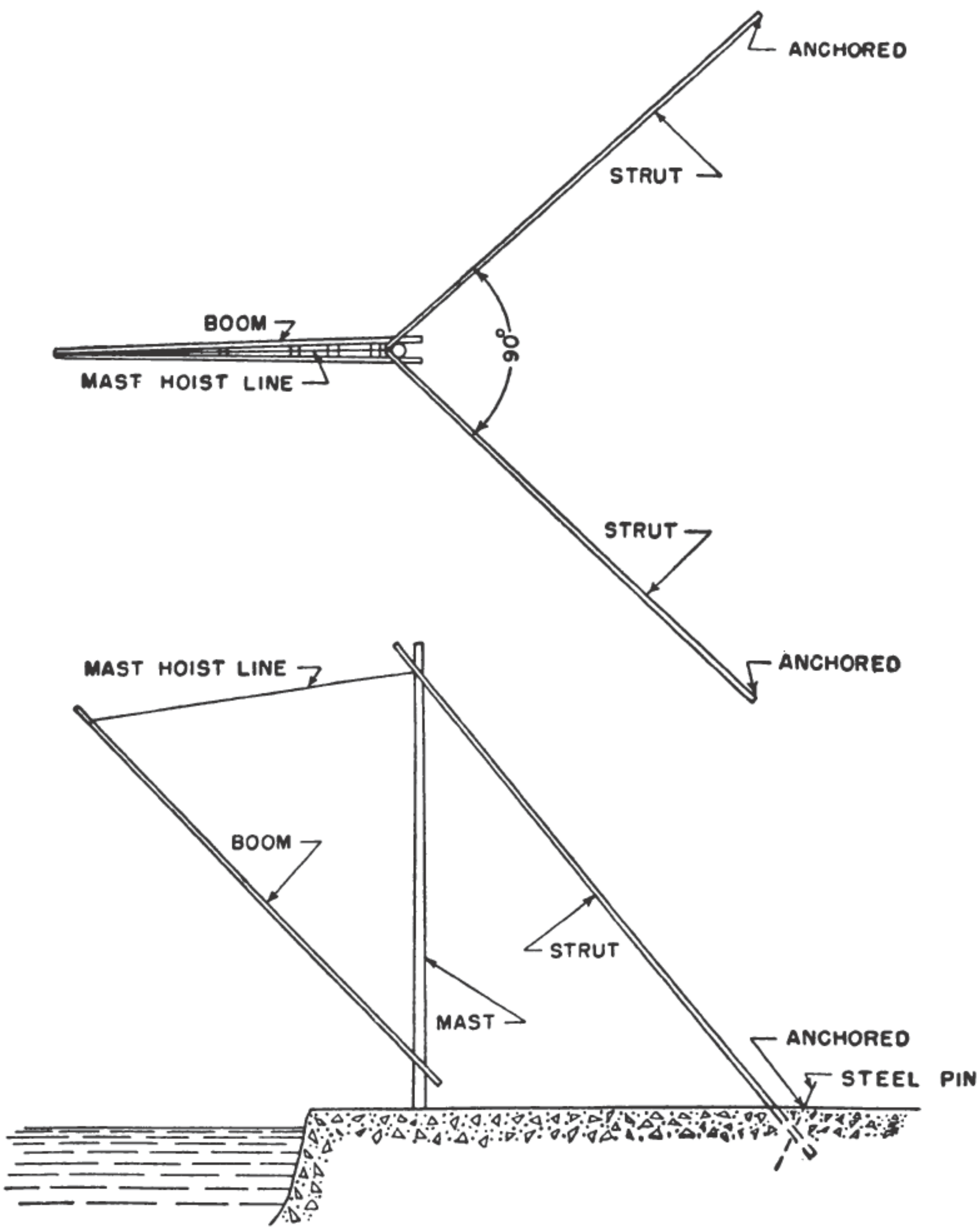


Figure 17-29.—Stiff-leg derrick.

a block lashed at the base of the mast. Before you raise the boom into position, CHECK ALL HOOKS to see that they are properly moused. To swing the boom, you can push directly on the load, or pull the load with tag lines.

Because of its design, the boom derrick has only a 120-degree horizontal swing. The swinging guy derrick, though, can swing a complete circle (360 degrees), because its boom is set on a bull wheel, and the mast and boom are rigged to swing together. This derrick is usually made from latticed steel sections, and is used in all types of construction work for making heavy lifts.

The stiff-leg derrick is similar to the boom derrick, except that the top of the mast is supported by 2 inclined struts instead of guys, and the boom can be longer. (See figure 17–29.) These struts must be SECURELY anchored. The boom of the stiff-leg has only a 120-degree horizontal swing. This kind of derrick is more stable, can be erected in a small area, and is the most permanent rig of the three.

LIVE A LITTLE LONGER

You've heard about the little man who wasn't there? Nine chances out of ten, it was because he forgot a six-letter word that packs more TNT than a torpedo's warhead. We're talking about that word SAFETY.

There are a lot of ghosts who once thought safety regulations were invented to slow down a job or to keep a fellow from enjoying himself. And if you're the kind who thinks a crutch is funny, maybe you've got the same idea. But it's pretty certain that since you've already come this far as a Builder, you've begun to appreciate what SAFETY means. You know that SAFETY IS NO LAUGHING MATTER.

As we described each part of your work as a Builder, we told you the important safety precautions. Remember what we said over and over again? DON'T DOPE OFF. The man who goes to sleep on the job is not only asking for it himself, but is a menace to his shipmates. You've

seen him in action. He's the one who daydreams about his big weekend date and promptly walks off the end of the scaffolding. Or maybe he sets a brick down on empty air—and it bounces off the head of his best friend below. So KEEP AWAKE—or you may sleep for a long time.

If you want to have a long happy life, DON'T BE A SMART ALEC. There's nothing funny in paying a hospital call on a friend who was hurt because you thought you were a comedian. There's danger enough on a construction job without adding to it by thoughtlessness. The mark of a good workman is the attention he pays to his task. There's no room for horseplay on the job.

Charity begins at home. And that's the way with SAFETY, too. The Navy doesn't give you safety helmets, gloves, shoes, and goggles to keep in your locker. They're to keep YOU from getting hurt—so WEAR YOUR PROTECTIVE CLOTHING. And don't let your shirt hang out like a bobby-soxer. Loose clothing or turned up cuffs can catch on a nail or a corner, and you'll be over the side or into a buzzsaw before you can say, "Oops!" One thing more. If you do get cut or scratched, get treated. A germ doesn't care if you lose a finger, but you do!

QUIZ

1. What are the two general kinds of rope?
2. What are the knots you'll have to depend on most in building operations?
3. Why is the square knot used to bend two lines together?
4. Assuming that you know the circumference of a line is 3 inches, how do you figure out the safe working load of any manila or hemp line?
5. What purpose does a thimble serve in an eye splice?
6. Clips are often used in connecting lines or making eyes. These clips are made up from a U-bolt and saddle. What is the main thing to remember when applying these clips?
7. If your rope has a diameter of 1 inch, how many clips would you use?
8. Name the eight parts of a block.

9. How do you figure the mechanical advantage of a purchase?
10. How can you increase the mechanical advantage by 4 to 1 of the luff tackle?
11. How should you control the swing of a load?
12. What is the rig known as the gin pole?
13. Why should a gin pole be no longer than 60 times its thickness?
14. How is the rig known as the A-frame formed?

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

THE BUILDER IN THE NAVY

1. You can learn to do you job well by observing building operations, asking questions, actual experience and practice, becoming building-minded, and by studying this book.
2. The general service rating combines the skills, duties, and knowledge of light and heavy construction.
3. The emergency service rating for Builder is divided into Builder L and Builder H.
4. The President of the United States is the Commander in Chief of the Armed Forces.
5. The Bureau of Yards and Docks exercises technical control over the Seabees.
6. The Departments of the Army, the Navy, and the Air Force comprise the Department of Defense.
7. The battalion is the basic organization of the Seabees.
8. The two types of organization used for the operational organization of the Seabees are the company and the industrial systems.
9. Handbooks and Navy Training Courses will help a Builder solve his problems.
10. Chapter 9, *Mathematics, Vol. 1*, contains information on scale drawings.

CHAPTER 2

LUMBER

1. Douglas fir, spruce, hemlock, and yellow pine.
2. Because it is easy to work.
3. Yellow pine, white pine, red oak, Sitka spruce, walnut, mahogany.
4. Doors, windows, cabinets, interior trim, and shelving.
5. Picture frames, toys, baskets, boxes, cheap furniture, and cabinet work.
6. Because of the resistance to decay.
7. Hickory.
8. Walnut, white pine, cherry, red cedar, and white-wood.
9. Cypress offers great resistance to decay.

10. Railroad ties, and shingles.
11. Hickory.
12. Mahogany.
13. The outer section of a tree between the heart wood and the bark.
14. The Cambium layer is the layer between the sapwood and the bark.
15. The faster method is called kiln-drying.
16. By color, weight, smell, feel, and visual examination of the chips and shavings.
17. Select or Common.
18. "Good on two sides."
19. Board feet.
20. The supports are termed "Scantlings" in the Navy.
21. Knots, which occur in almost all kinds of lumber.
22. Wall board and insulation board.

CHAPTER 3

SURFACE PREPARATION FOR PAINTING

1. The preparation of lumber before it becomes finished work consists of planing, scraping, and sandpapering.
2. The jack plane, smooth plane, and block plane are the three types of planes used most frequently by a builder.
3. The jack plane is used for smoothing rough surfaces and planing boards to size and squareness.
4. The cut of the jack plane is made with the grain of the wood.
5. The smooth plane is used for fine work on small pieces of stock.
6. The block plane is used for trimming end grain and making close fitting joints.
7. After planing and before sandpapering is the time to use the scraper.
8. Gasoline and benzine are fire hazards.
9. Sea sand is not used in making sandpaper because the edges have been worn dull.
10. The two types of sandpapers are natural abrasives and artificial abrasives.
11. The usual procedure in sandpapering is to first use a coarse grade of sandpaper, and then go over the surface with a finer grade.
12. The teeth's spacing and the angle at which the teeth cross is termed "the cut of the file."
13. Single- and double-cut files are classified as rough, bastard, second-cut, and smooth.

14. Sandblasting is considered the most satisfactory method of obtaining a clean surface for masonry painting.
15. The first requirement of the plaster surface is that it be smooth.
16. The application of two pounds of zinc sulfate crystals dissolved in ½ gallon of water will prevent a lime reaction on the paint.
17. Red lead is the best protective paint for iron or steel.
18. Chalking, alligatoring, peeling, bleeding, blistering, checking, cracking and scaling, crawling, fading, loss of gloss, running and sagging, tackiness and slow drying, and wrinkling are different types of paint failures.
19. You can learn to do your painting assignment well by observing painting operations, actual experience and practice, and studying this Navy course.

CHAPTER 4

COMPOSITION AND STORAGE OF PAINT

1. Mineral spirits is usually added to make paint thinner.
2. Oil and spirit varnishes are the two types of varnishes used by the Navy.
3. Thinners in paint are used to reduce the consistency of the paint to the proper degree for application by spraying or brushing.
4. The primer most frequently used by the Navy is zinc chromate.
5. The drier in paint conveys oxygen from the air to the oil in the paint, thus speeding up the drying process.
6. Pour off most of the clear liquid, and mix the remainder thoroughly; add a small amount of the clear liquid and continue the process of mixing until the whole has been made homogeneous. The final step is to pour the paint back and forth between two cans.
7. "Application of Color to Shore Establishment."
8. 26.
9. Paint is poured back and forth between two cans several times.
10. b. wood alcohol.
11. Zinc dust water-tank paint, aluminum paint, and nonskid deck paint.

CHAPTER 5

EXTERIOR AND INTERIOR PAINTING

1. The first and foremost job of paint is to preserve surfaces.
2. Paint is used for the protection and preservation of surfaces; as an aid in maintaining sanitation and cleanliness; to reflect, absorb, or redistribute illumination; to promote safety and efficiency; as camouflage or for obscurity; and to improve appearance.
3. The flat and the fitch brushes are the two most commonly used in the Navy.
4. A brush on which too much pressure is exerted in the center will wear into a fishtail shape.
5. To prevent bristles in a round brush from spreading, bind the heel end with cotton line.
6. The correct method of applying paint is to first "lay on," then "lay off."
7. To prevent brush marks when finishing up a square, use strokes directed toward the last square finished, gradually lifting the brush near the end of the stroke while the brush is still in motion.
8. The two types of spray guns are the container type, and the separate container type.
9. The two elementary rules for paint spraying are: (1) the spray gun must be thoroughly clean, and (2) you must have plenty of air at the gun.
10. To spray corners, first spray up to within one or two inches of the corner, then turn the gun on its side, and starting at the top spray downward along the edge so you will catch both sides of the corner at once.
11. The common failures in spray painting are "orange peels," runs and sags, pinholes, blushing, peeling, and bleeding.
12. The three types of roller coaters are dip, can, and pressure.
13. The process of setting glass in the sash with putty is known as glazing.
14. Glass is graded as double-thick and single-thick; each thickness is further subdivided into three qualities: first, second, and third.
15. Pressing the glass into the putty to an even bearing in the window is called bedding.
16. Filling the rabbet of the new glass with putty and smoothing off with a putty knife is called "face puttying."

17. If the surface is already painted apply masking tape to both sides of the stripe, before painting the stripe; if the surface has not been painted, first decide on the position and width of the stripe, then spray or brush the color on, allowing it to overlap the edge of the stripe a little on both sides. Cover the stripe with masking tape, and proceed with painting.
18. Accidents in painting are usually caused by faulty lines, cables, work platforms, ladders, and scaffolds.
19. A paint striper requires neither brush nor spray gun.

CHAPTER 6

WOODWORKING TOOLS AND BUILDING HARDWARE

1. Nails are commonly classified as wire nails and cut nails.
2. Nails, spikes, and brads.
3. Brads, finishing nails, casing nails, box nails, common nails, and spikes.
4. To secure logs and heavy timbers.
5. Use one size larger nail on soft wood than you would use on hard wood.
6. Flathead, round head, oval head, and fillister head.
7. A heavy duty screw made with a square or hexagonal head.
8. Stove bolts, carriage bolts, and machine bolts.
9. To prevent the nut or head of the bolt from being drawn into the wood.
10. When you fasten wood to metal by means of bolts.
11. A miter box is a device used to cut angles in making an accurate angle joint.
12. The scratch awl is used to mark wood for fine jointing.
13. For making the inside measurements of openings.
14. With a grinding wheel and an oil stone.
15. Reaming and countersinking screws and bolts.
16. To make a hole for starting a nail or screw.
17. Twist and the shell gimlet.
18. The gimlet is driven into the wood by half turns, releasing and regrasping the handle at each half turn.
19. Auger bits, fostner bits, gimlet bits, plug bits, ship-auger bits, expansive bits.

CHAPTER 7

POWER TOOLS

1. The plain dado is usually cut with a dado head.
2. A small wooden strip inserted in a slot or groove between two pieces of wood to join them together.
3. A mortise-and-tenon joint consists of an opening or mortise on the side of one piece, and a specially shaped end or tenon on the other piece.
4. Rough work, such as cutting subfloor and roof sheathing.
5. By the size of the wheels.
6. The blade moves up and down, cutting on the down stroke.
7. Truing up and squaring edge and face surfaces of boards.
8. To avoid burning the tool.

CHAPTER 8

BLUEPRINTS AND THE STEEL SQUARE

1. In working drawings and specifications.
2. In order to leave the proper spaces for plumbing and electrical equipment.
3. On the working drawings.
4. Plot plan, footing and foundation plans, floor plans, section plans, elevations.
5. The pitch of the roof.
6. How the building is to be erected.
7. When a framing table and various other scales are stamped on the square.
8. The tongue, blade, and heel.
9. Scales and tables.
10. Rafter or framing table, essex table, and brace table.
11. Octagon scale, hundredths scale, inch scale, and diagonal scale.

CHAPTER 9

FOUNDATION AND FORM BUILDING

1. To be sure that the supports are strong enough, and are well braced.
2. To insure uniform thickness.
3. 20′ x 48′ Quonset Huts, light frame buildings, and prefabricated structures.

4. The lower expanded portion of a foundation which rests on the surface, at the bottom of the excavation.
5. Common and flemish bond.
6. Crosswise of the wall to bind the wall in a transverse direction.
7. Form oil, stainless grease, or soft soap.
8. To prevent the wall above from being pushed off the footing by earth pressure.
9. To prevent a cave in.
10. It is better to leave forms on too long than to remove them too soon.

CHAPTER 10

CONCRETE

1. Ninety-four pounds net.
2. Because hot cement may become quick-setting.
3. In a waterproof structure and at least eight inches from walls, ground, or deck.
4. A mixture of sand, water, and a cementing material in proper portions.
5. By laying mortar between them.
6. Broken stone, gravel, cinders, or slag mixed with a mortar of sand, cement, and water.
7. The inert materials which are bonded together with cement to make concrete.
8. Because foreign materials prevent good bond between cement and sand.
9. Only in an emergency.
10. Only water that is fit to drink.
11. The slump test.
12. By the bag, which contains one cubic foot.
13. The number of bags of cement required.
14. By hand or by machine.
15. That 1 part of cement is mixed to 2 parts of sand and 3½ parts of suitable aggregate.
16. "Curing."
17. Any concrete in which steel in any shape, or wire netting is placed.

CHAPTER 11

SCAFFOLDING AND STAGING

1. Good material, proper nailing, and good workmanship.
2. Two-platform, framed portable-supported, and portable scaffold.

3. Working on staging which does not have a back rail, and working where tools and materials are scattered carelessly on elevated decks.
4. It is not strong enough and may warp or crack when it begins to dry.
5. The ends of all scaffolding and staging platform boards must be supported and made fast.
6. For renovating and installing high ceilings.

CHAPTER 12

WOODWORKING

1. The plain butt joint, dowel joint, tongue and groove joint, and the spline.
2. The edges to be joined are squared and then glued together.
3. Flooring.
4. For joining heavy timbers.
5. Fish plates.
6. Because of its locking feature.
7. Picture frames, screen doors, and panel frames.
8. Animal glue.
9. Nails, screws, bolts, and glue.
10. No.
11. Milk in powdered form.
12. No.
13. To prevent the glue from setting before the excess glue can be squeezed out.

CHAPTER 13

FRAMING

1. The floors, walls, and roof.
2. Laminated, solid, lapped, and box sill.
3. Stronger and easier to install.
4. The members which make up the body of the floor frame.
5. One that extends from one sill to the other and helps support the uniform load.
6. In order to give added support to the well hole or opening.
7. To prevent the floor joist from springing sideways under a heavy load.
8. Herringbone or cross bridging and solid or plank bridging.
9. At 8- to 10-foot intervals.
10. To give added strength to the structure.

11. To tie the studdings together at the top, to act as a support for the rafters, and to support the ceiling joist.
12. The member that carries the bottom end of the studs.
13. Let-in bracing.
14. The slope of the roof.
15. The shortest line between the two opposite rafter seats.
16. Any line that is vertical when the rafter is in its proper position.
17. Common, jack, hip, valley, and cripple rafter.

CHAPTER 14

PREFABRICATED STRUCTURES

1. Steel sills, joists, and channel plates.
2. To level and tamp an area of ground 30′ x 60′ for the hut site.
3. In 5 parallel lines about 5 feet apart.
4. 4′ x 8′ plywood panels nailed to the floor joists.
5. Two end panels, two window panels, and one door panel.
6. The 6-inch channel plates.
7. After the channel plates have been laid.
8. In three longitudinal strips. The two outside strips are 14′ wide and the center strip is 12′ wide.
9. Nails.
10. Setting the channels, raising the ribs, framing the bulkheads, and applying the covering.

CHAPTER 15

FIELD STRUCTURES

1. Housing, storage, and messing.
2. Because tents that are on a rigid frame will be carried away, while those that are collapsed and held down with sand bags will ride out the gale.
3. To close automatically.
4. With tar paper from the top to the bottom.
5. So as not to come under the holes of the latrine box.
6. To dispose of garbage.
7. Easiest to build and more efficient.
8. So trucks can get to incinerator to dump garbage into the hopper.
9. Form, texture, shadow, and color.
10. Because it quickly attracts the eye.
11. Carry them past their destination.

12. By covering the windshields with a coat of dust or mud.
13. So the appearance will be the same.
14. By using branches, and garnished nets.
15. False structures made to look like the real building or article.
16. Yes.

CHAPTER 16

WATERFRONT STRUCTURES

1. The quay is a bulkhead or wall parallel to the shoreline with solid fill behind it.
2. Driving a steel-sheet pile bulkhead.
3. Bearing, batter, fender, dolphin, mooring, and sheet piles.
4. A cluster of piles held together by bolts and a wrapping of cable.
5. Interlocking piles of wood or steel which can be driven into the ground to form a continuous wall or bulkhead.
6. By ranges or grids laid off by a Surveyor.
7. A follower or dolly.
8. With driving caps.
9. Gang driving.
10. By driving a timber pile along the proposed line of the wall and then securing a wale to them.
11. To keep the completed bulkhead in line.
12. To resist the pressure of the water and the pressure of the earth fill.
13. When soil conditions do not meet the required specifications or where fill is to be placed by the hydraulic method.
14. Wood dwelling and ground dwelling.
15. A heavy creosoting treatment.

CHAPTER 17

RIGGING AND ASSEMBLIES

1. Vegetable fiber and steel, iron, or bronze.
2. Overhead, square, bowline, and timber hitches.
3. Because it won't slip under a heavy load.
4. $C^2 \times 150$ lbs. $= 3 \times 3 \times 150 = 1350$ lbs.
5. Keeps the wire rope from bending too much, and makes the rope wear longer.
6. Place the U-bolt on the end and the saddle on the standing part.
7. $3D \times 1 =$ number of clips.
   $3 \times 1 + 1 = 4$ clips.

8. Frame, sheave, pin, strap, cheeks, swallow, breech, and becket.
9. Count the number of falls above the movable block.
10. By attaching the weight to the double block.
11. By using a tagline.
12. A single pole, timber, or steel beam, held almost upright by guys.
13. Because it will buckle under a heavy load.
14. By bolting or lashing two timbers, poles, pipes, or steel bars together near the top to form what looks like the letter "A."

APPENDIX II

QUALIFICATIONS FOR ADVANCEMENT IN RATING

BUILDERS (BU)

Rating Code No. 5600

General Service Rating

Scope

Builders construct, erect, maintain, and repair wooden and concrete structures; perform pile driving operations; operate carpenter and woodworking shops; perform sawmill operations; mix and apply paints; build concrete forms, place reinforcing steel, and batch, mix, and place concrete for all types of structures, including underwater installations.

Emergency Service Ratings

BUILDERS L (Light Construction), Rating Code No. 5601 **BUL**
Construct, erect, maintain, and repair light construction such as wooden, concrete, and prefabricated buildings.

BUILDERS H (Heavy Construction), Rating Code No. 5602 **BUH**
Construct, erect, maintain, and repair heavy construction such as water-front structures, cofferdams, and trestles.

Navy Job Classifications and Codes

For specific Navy job classifications included within this rating and the applicable job codes, see Manual of Enlisted Navy Job Classifications, NavPers 15105 (Revised), codes BU–5900 to BU–5999.

QUALIFICATIONS FOR ADVANCEMENT IN RATING

Qualifications for Advancement in Rating	*Applicable Rates*		
	BU	BUL	BUH
100 PRACTICAL FACTORS			
101 OPERATIONAL			
1. Operate:			
a. Power-driven portable saws and hand drills	3	3	3
b. Portable concrete mixers. Charge concrete mixers according to instructions and mix specifications	3	3	3

Qualifications for Advancement in Rating	BU	BUL	BUH
101 OPERATIONAL—Continued			
2. Assist in setting grade stakes and batter boards for building construction	3	3	3
3. Read simple working drawings and sketches	3	3	3
4. Prepare surfaces for painting and varnishing	3	3	3
5. Use hand tools found in:			
a. Carpenter's kit	3	3	----
b. Dock builder's kit	3	----	3
6. Serve as helper in construction and erection of water-front structures, trestles, and coffer-dams	3	----	3
7. Serve as helper in erection of prefabricated structures	3	3	----
8. Place and tie, under supervision, steel for reinforced concrete	3	3	----
9. Perform slump tests on concrete	3	3	----
10. Mix mortars and grouts for masonry construction	3	3	----
11. Construct and erect under supervision:			
a. Rough carpentry	3	3	----
b. Finish carpentry	2	2	----
c. Water-front structures, trestles, and cofferdams	2	----	2
12. Operate planers, band saws, jointers, sanders, and other woodworking shop equipment	2	2	2
13. Read and work from building plans and specifications	2	2	2
14. Erect and use gin poles and A-frames to hoist construction materials. Act as hook-on man in loading and unloading construction material with cranes or hoisting equipment	2	2	2
15. Mix and apply paints and varnishes	2	2	2
16. Act as pile setter by rigging, placing, and guiding piles	2	----	2
17. Construct and erect field-type latrines, incinerators, and camouflage structures. Erect prefabricated buildings and tents	2	2	----
18. Finish concrete to required grade and type of surface. Direct placing operations. Operate concrete vibrators	2	2	----

Applicable Rates: BU, BUL, BUH

Qualifications for Advancement in Rating		BU	BUL	BUH
101	OPERATIONAL—Continued			
	19. Use engineer's level to set grade stakes and batter boards for building construction	1	1	1
	20. Erect and calk wooden stave tanks at advanced bases	1	1	1
	21. Prepare sketches to be used for carpentry and concrete form work	1	1	1
	22. Rig temporary wooden members to hold in place walls and structures during construction	1	1	1
	23. Lay out and mark wooden members for cutting and placing	1	1	1
	24. Build cabinets, desks, chairs, boxes, and similar items according to sketches and instructions	1	1	----
	25. Act as sawyer in operation of portable sawmill	1	----	1
	26. Build and install exterior and interior finish carpentry in accordance with plans, sketches, instructions, and specifications	1	1	----
	27. Determine and measure charges for producing required concrete mixes. Make and interpret field tests of concrete	1	1	----
	28. Lay bricks, cinder blocks, and building tiles	1	1	----
102	MAINTENANCE AND/OR REPAIR			
	1. Clean and lubricate portable concrete mixers, concrete vibrators, and power-driven portable saws and hand drills	3	3	3
	2. Maintain and repair hand tools found in:			
	a. Carpenter's kit	3	3	----
	b. Dock builder's kit	3	----	3
	3. Maintain planers, band saws, jointers, sanders, and other woodworking shop equipment	2	2	2
	4. Repair prefabricated buildings, field-type latrines, and incinerators	2	2	----
103	ADMINISTRATIVE AND/OR CLERICAL			
	1. Estimate materials for wooden and concrete structures from working drawings, sketches, and specifications	1	1	1

Qualifications for Advancement in Rating	Applicable Rates BU	BUL	BUH
101 OPERATIONAL—Continued			
2. Prepare job progress reports, work orders, and material requisitions	1	1	1
3. Act as carpenter foreman or labor foreman of a detail engaged in:			
a. Building construction work	1	1	----
b. Concrete work	1	1	----
c. Pile-driving operations	1	--	1
d. Sawmill operations	1	--	1
e. Construction of trestles, water-front structures, and cofferdams	1	--	1
f. Carpenter and woodworking shop work	1	1	--
4. Supervise and train personnel engaged in:			
a. Building construction work	C	C	--
b. Concrete work	C	C	--
c. Pile-driving operations	C	--	C
d. Sawmill operations	C	----	C
e. Construction of trestles, water-front structures, and cofferdams	C	----	C
f. Carpenter and woodworking shop work	C	C	----
200 EXAMINATION SUBJECTS			
201 OPERATIONAL			
1. Hand tools and materials commonly used in construction of wooden and concrete structures	3	3	3
2. Terminology of structural members of buildings, water-front structures, concrete forms, cofferdams, and trestles	3	3	3
3. Standard hand signals for hoisting operations	3	3	3
4. Nominal and actual size of lumber. Method of computing board feet	3	3	3
5. Methods of cutting and joining wooden members	3	3	3
6. Methods of using and stripping wooden and metal concrete forms	3	3	3
7. Methods of preparing surfaces for painting and varnishing	3	3	3
8. Safety precautions to be observed in performance of building construction jobs	3	3	3

Qualifications for Advancement in Rating	*Applicable Rates*		
	BU	**BUL**	**BUH**
201 OPERATIONAL—Continued			
9. Methods of mixing and uses of mortars and grouts for masonry construction	**3**	3	----
10. Types of standard advanced-base prefabricated structures	**3**	3	----
11. Methods of erection and uses of gin poles and A frames. Kinds and sizes of wire and manila rope used for swinging scaffolds and rigging gin poles and A-frames	**2**	2	2
12. Methods of grading aggregate	**2**	2	2
13. Construction and use of camouflage structures	**2**	2	----
14. Characteristics and uses of concrete mixes. Methods of mixing, placing and finishing concrete. Reasons for and methods of curing concrete	**2**	2	----
15. Types and uses of piles; methods of driving piles	**2**	----	2
16. Methods of applying paints and varnishes	**2**	2	----
17. Methods of placing concrete under water	**1**	1	1
18. Layout of structural members in wooden structures	**1**	1	1
19. Methods of constructing and uses of cofferdams	**1**	----	1
20. Methods of laying bricks, cinder blocks, and building tiles. Methods of laying and cementing stones to form walls, piers, and abutments	**1**	1	----
21. Methods of determining amounts of materials required for concrete mixes	**1**	1	----
22. Safety precautions to be observed in planning and supervising accident prevention programs on building construction jobs	**C**	C	C
23. Basic procedures used in erecting and dismantling steel structures	**C**	C	C
24. Common structural steel shapes	**C**	C	C
25. Fabrication of a pontoon. Assembly and uses of pontoon structures	**C**	C	C
26. Methods of laying out, bracing, and erecting concrete forms	**C**	C	C

Qualifications for Advancement in Rating		Applicable Rates		
		BU	BUL	BUH
201	OPERATIONAL—Continued			
	27. Layout, assembly, and operation of concrete batching plants	C	C	----
202	MAINTENANCE AND/OR REPAIR			
	(No minimum qualifications.)			
203	ADMINISTRATIVE AND/OR CLERICAL			
	1. Functions of operational companies of a Construction Battalion	3	3	3

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